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Automatic Tuning!

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Journal
of
The Franklin Institute
Devoted to Science and the Mechanic Arts

Vol. 238 NOVEMBER, 1944 No. 5

NUTRITIONAL ENGINEERING, IV:
FROM WARTIME SITUATIONS TO PEACETIME POLICY.

BY

HENRY C. SHERMAN,

Mitchill Professor of Chemistry, Columbia University, New York City.*

The previous papers of this series have summarized the present-day scientific concept of the nutritional improvability of life and the use of food supplies and food-production resources with reference to our wartime problems. The paper which here follows undertakes to explain how the same scientific principles can guide us from the food-situations involved in the emergency of winning the war to such a nutrition policy for the future as shall best contribute to a stable peace.

As Sir John Orr repeatedly pointed out, even before the war, the new knowledge which shows that nutrition has much greater potentiality for health and welfare than had previously been conceived, coming at the same time with greatly increased power to produce and distribute food, has created a situation quite different from any that has existed before, and which calls for a new kind of statesmanship.

It was largely in recognition of this fact that food was given the leading place in the first meeting of representatives of the peace-minded nations of the world. And while this United Nations Conference on Food and Agriculture "had a very bad press," its official proceedings show a distinct awakening on the part of the peoples and the governments of the world to the fact that food is not only an immediate necessity but also has hitherto unknown potentialities of constructive influence upon the quantity and quality of human life that each nation, or that a peaceful family of nations, can enjoy if its people sufficiently *will*.

---

* From April 1, 1943 to June 30, 1944, Chief of the Bureau of Human Nutrition and Home Economics, Agricultural Research Administration, U. S. Department of Agriculture, while on leave of absence from the University for this special emergency service.

(Note—The Franklin Institute is not responsible for the statements and opinions advanced by contributors in the JOURNAL.)

As one of the resolutions of the United Nations Conference set forth, we can no longer properly blame either a lack of human knowledge or "the harshness of Nature," if from now on we continue to permit people to be frustrated in their lives for lack of the food that is essential to health. And this, as Lord Astor had concisely put it, "means not only enough food but also enough of the *right kinds* of food."

With the world now awakened to the fact that recent advances in the science of nutrition offer man a new order of mastery of his life history, it seems reasonable to hope that every reader of these pages will in some measure desire to have a part in this far-reaching constructive enterprise of today. We can all be architects of the higher health, or nutritional engineers of the human life process, by using the guidance of scientific knowledge in our everyday choices of food. For these choices inevitably exert both the educational influence of example and the economic influence of "consumer demand." Both these are more far-reaching than one might at first think. For better or worse, our fellowcitizens of today probably believe as much in science as in anything; and probably they regard each of us (students and workers in science) as in some degree an *exemplar* of the scientific way of life. Each of us who reads this JOURNAL, even if he should never utter a word of precept, is yet by daily example an extension-teacher in whatever aspects of scientifically sound living-habits he may exemplify. Moreover, in these days, the progress of science and the food problems of the war have so combined to make *news* of foods and nutrition, that ordinary conversation is almost certain to call upon every scientifically-minded person to disseminate by statement (as well as by example) the principles and significances of nutrition and food values. Of these nearly everyone has heard some fragments and desires the more coherent views that may normally be expected from those of us who have more scientific background, whether professionally trained in nutrition or not.

In addition, every person as a consumer of food exerts an economic influence upon food production, and thereby also a governmental influence upon nutrition policy. This is true whether the consumer is conscious of it or not, and whether few or many legislators and government officials think in terms of clearly perceived food-and-nutrition policies. For in a democracy as pragmatically minded as ours, Government shapes its policies upon its judgment as to what the people want as expressed not only in words but also as consumer demand in the food market. *Effective market demand* depends so directly upon what the people *in some sense* "want," that it inevitably weighs heavily in the scales of judgment both of policy-making governmental executives and of legislators.

In a democracy the individual choice of food "counts," and it is logical to exercise thoughtfulness and civic responsibility in choosing what foods one shall use and how much of each.

In April, 1944, on the basis of a report of its Food and Nutrition Board, the National Research Council issued a statement entitled, *How We Can Share Our Food and Maintain Good Nutrition At Home.* In a discussion of the food situation and the Government's production goals, along lines indicated in the preceding paper of the present series, the National Research Council's statement included the following recommendation which bears directly upon and specifically illustrates the question of choice of food:

"*Foods to be Emphasized* * *under the Plan here Recommended.—Milk products* (with maximum practical use of all dairy products for human consumption, including: fluid milk, butter, skimmilk, cheese, and whey); *Vegetable fats* (including margarine fortified with vitamin A); *Meat of range and pasture fed* (as opposed to grain fed) *animals; Fish and shellfish; Eggs; Other protein foods* (dry beans, peas and soybeans, nuts, peanuts and peanut butter, soybean flour and grits); *Cereals* (bread and other wheat products, whole grain or enriched, oatmeal, corn meal and enriched grits); *Citrus fruits and tomatoes; Less perishable vegetables* (potatoes, sweetpotatoes, mature onions); *Green and yellow vegetables* (broccoli and kale, cabbage and brussels sprouts, carrots . . . , green peppers, leaf lettuce, mustard greens, yellow fleshed pumpkin and squash, snap beans, turnip greens); *Locally grown fruits and vegetables generally.*

"These foods can augment the national nutrient supply most economically in terms of land, manpower, and equipment and can be distributed with a minimum of wastage and of special facilities for their preservation. Among them are no foods which would be rejected by any considerable part of the population by virtue of food habits, taste, or religious taboos. This list of foods-to-be-emphasized should be helpful in determining allocations for farm equipment, processing machinery, and scarce materials for packing. It reflects what might well be a major administrative consideration in determining plans for production incentives such as support prices, subsidies, and transportation priorities."

This National Research Council statement was issued as applying to the 1944 situation and that of the duration of the emergency.

In the opinion of the present writer it also epitomizes much of the central thought which we may hope has been sufficiently learned under the pressure of the war situation so that it should carry over into our permanent food-and-nutrition policy.

There is no doubt of the permanent desirability of a greater prominence of fruit, vegetables, and milk in the dietaries of most individuals and families and in the food supplies of most nations. Both for economic reasons and for fullest utilization of their vitamin values, it should be the policy of this country and most others to give permanent encouragement to local production and consumption of these perishable protective foods. This is consistent with the development *also* of such methods of preservation and transportation as shall result in fuller international trade in the fruits of the regions best suited to specialize in their production, and with optimal conservation of their flavors and nutrient virtues. Thus, whether we are thinking in terms of individual and family *nutrition policy* or that of a nation or family of nations, any policy which sufficiently recognizes the newer knowledge of nutrition will give a growing place to fruits, vegetables and milk in the food supply.

---

* The degree of emphasis will differ with circumstances. Any attempt at rigid definition would be undesirable. This list includes items of varying degrees of importance. It is based primarily on nutritional considerations and does not include commodities chiefly significant as flavorings or food adjuncts.

It will also be recognized that on practical grounds, these bulky, watery, perishable foods will be largely produced in the general regions in which they are to be consumed, and that the less perishable, more concentrated, foods, such as grains and breadstuffs, meats and fats, will enter more largely into over-seas shipments.

This policy should obviously appeal to common sense, both for the period of emergency food relief and for as long a future as we can foresee. For it is clearly sound economically and nutritionally. Countries suffering from severe food shortage will be thinking first in terms of bread or its equivalent. And next in order of their desires, as to foods that we can send them, will usually come fats, or meats, or both.

We can confidently expect these facts to hold good both for the period of the present emergency and for the longer future as well.

Shipping conditions will for some time tend to keep the emphasis in the directions just stated, and during this time the liberated countries will be reëstablishing their home production of fruits and fresh vegetables rapidly, and of dairy products as rapidly as circumstances permit. And, as conditions approach normal, it will become increasingly apparent that Europe can produce fruits, vegetables, and dairy products for its own use as cheaply as it can import them; while grains (and perhaps the "fuel foods" generally) can, in the absence of artificial restrictions, be imported into Europe more economically than they can be produced there.

For some years to come, we in America may ourselves incline to give bread and cereals a somewhat larger place in our dietary, as part of a policy to make more efficient use of our food-production resources until we have emancipated our low-income fellowcitizens from malnutrition.

So, even though we may not know in advance how much grain we shall wish to send overseas, it will be wise to keep up a relatively high production of grain crops, and especially wheat. Wheat is so highly appreciated in practically all parts of the world that a good reserve store of wheat will be a potent asset for the winning both of the war and of the peace. And reserve stores of any or all of our grains can always be used, with great advantage to our nutrition, either for direct human consumption or to increase milk production.

For it is one of the most certain teachings of the newer knowledge of nutrition, and should always be held clearly in mind, that even though we in the United States have more milk per capita than most other peoples we still need more for our *best* nutritional wellbeing and resultant health and efficiency. Milk is the outstanding source of both calcium and riboflavin—the two nutrients in which American dietaries most often fall below the generally accepted recommendations. And in other respects also, milk is now known to hold a place of unique importance in making our dietaries well balanced, and in doing this at low cost to the consumer, and with inherent economy and efficiency of the agricultural resources used in its production.

The shifting into milk production of a part of the grain hitherto fed to meat animals, is a very important feature of the present trend of the food-production goals of the United States Department of Agriculture and of the above-quoted statement issued by the National Research Council. While there is now (July 1944) practically unanimous agreement upon this policy, as combining the advantages of an inherently more economical and efficient use of the nation's resources for food production, and the improved nutrition of its people, there is danger that the strong traditional inclination to a high rate of meat consumption as a part of the American standard of living may lead some people to backslide into a mistaken tradition of "normalcy" as soon as the war emergency is over; whereas those more appreciative of the nutritional importance of this policy, and also of its broader human implications, are strongly of the opinion that a moderate shift in the direction of the Department of Agriculture production goals for 1944 should be permanent.

As explained above, this paper is written in the hope that each of its readers will play a part in making the atmosphere of public opinion which must largely influence the outcome of our food situation. The reader is presumably a consumer of both meat and milk, in some form, and there is no suggestion of giving up either. The question is only as between a little more or less of the one or the other. A shift to a slightly higher proportion of milk will in nearly all cases mean a better balanced diet and a larger nutritive value for the same expenditure of money. This is permanently true because the grain-fed meat is inherently more expensive of resources to produce. So the consumer's shift of emphasis toward more milk not only brings him a better diet at the same or less cost, but also economizes the country's resources. If less grain-fed meat is demanded and produced, more grain will be spared for the production of breadstuffs or cereals and of milk, for those who need more of these foods.

Now that we have (actually, though we trust only briefly) experienced the practical depletion of our usual reserves of grain, we see that there is no room to doubt the fact that the consumer demand for grain-fed meat, by those who have the more money to spend, makes it harder for the families of lower income to get the bread and milk that they need for health.

The elementary facts of nutrition that such matters of food habit or food policy involve are rapidly becoming widely known to people who thereby begin to realize, as no one could realize before, how the impoverishment and thwarting of human lives is largely due to the limitations of the dietaries that are economically available to low-income families. Both materially and morally it would diminish the strain caused by disparities of economic condition, if the people of higher income would forgo such food habits as are inherently expensive of food-production resources.

And similarly, goodwill between nations can be promoted, by our development of an attitude of willingness to make common cause in the winning (for all peoples) of freedom from want in peacetime, as the United Nations have worked together for the winning of the war. Looking at the matter with the open mind of our professedly scientific age, one cannot fail to see the advantage to permanent peace of an amelioration of such disparities as that the per capita demand upon food-production resources is five to ten times as great in some of the United Nations as in others. Our present knowledge of nutrition, of food technology, and of agriculture shows us how more equitable arrangements can be made; and it is clear that such better use of our scientific knowledge can strongly implement the development of such worldwide social justice as is needed to insure the peace.

If our war emergency regulations are to be succeeded by something in the way of a legally enacted food policy, it would seem that account should be taken of these human implications; while if only the unwritten policy of daily food choices is to prevail, we might well consider, in the interest of both internal and international goodwill, the voluntary promotion of a reform of such of our food habits as are so expensive of resources as to constitute an undue flaunting of economic disparity.

Obviously the space here available would not permit the discussion of all of the points that the title of this paper may suggest. Some of them have been covered in previous papers of the series, and others would be too speculative at present. For instance, it has already been explained that soybean oil has made us much less dependent upon lard; and it is not yet known to what extent soybean protein will be adopted into the American dietary of today.

Nor is it our purpose to enter into administrative questions.

Rather we have here sought to present a few central ideas of food policy as they appear from the scientific approach. This has involved a glance at one problem of choice between science and tradition. And it suggests the question whether, if we choose to be scientists rather than traditionists, we should undertake the responsibilities of a sort of stewardship of science with respect to its broader human implications.

DYADIC ANALYSIS OF SPACE RIGID FRAMEWORK.

BY

CHEN PEI-PING,

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I. SUMMARY.

Any space framework consisting of prismatic beams and rigid joints may be analyzed exactly by solving a set of simultaneous linear vector equations with dyadic coefficients. The iteration method may be applied equally well.

II. GENERAL RULE.

1. Notation.

Use $A, B, C, \cdots$ for scalars,
$a, b, c, \cdots$ for vectors,
$\Phi, \Psi, \cdots$ for dyadics,
and $\phi, \psi, \xi, \cdots$ for nondimensional dyadic factors.

2. Use joint convention instead of beam convention.

3. Force, displacement, moment, and rotation are vectors, the sense of the latter two being determined by the right hand rule.

4. Let i, j, and k be the three nondimensional unit vectors along the torsion axis and the principal bending axes at the centroid of the beam cross section so that these vectors form a right hand orthogonal system.

5. Other assumptions:

- i. That the principle of superposition is applicable.
- ii. That the external loads are applied at the joints or at the beam ends (otherwise see VI).
- iii. That the secondary effect may be neglected.
- iv. That the length and direction of any beam are not affected by the strained condition of this framework.

III. FUNDAMENTAL VECTOR EQUATION FOR A BEAM.

Assume that the external forces f_1, f_2 and external couples m_1, m_2 are applied at the ends of a beam (Fig. 1). It is required to find the relations between the loads, the displacements d_1, d_2 and the rotations a_1, a_2 at both ends.

Resolve each vector into three components along the three beam axes, e.g.,

$$f_1 = iF_{1i} + jF_{1j} + kF_{1k}, \text{ etc.}$$

From statics, it gives

$$F_{2i} = -F_{1i}, \quad F_{2j} = -F_{1j}, \quad F_{2k} = -F_{1k},$$

$$M_{2i} = -M_{1i}, \quad M_{2j} = -M_{1j} - F_{1k}L, \quad \text{and} \quad M_{2k} = -M_{1k} + F_{1j}L,$$

or, written in the vector form,

$$f_2 = -f_1, \tag{1a}$$

and

$$m_2 = -m_1 + (kj - jk)\cdot f_1 L. \tag{1b}$$

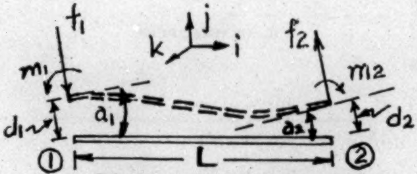


Fig. 1 A beam

Similarly from strength of materials, it gives

$$(a_1 - a_2)\frac{E}{L} = \left(\frac{-kj}{2I_k} + \frac{jk}{2I_j}\right)\cdot f_1 L + \left(\frac{CE}{GI_i}ii + \frac{jj}{I_j} + \frac{kk}{I_k}\right)\cdot m_1, \tag{1c}$$

and

$$[d_1 - d_2 - (kj - jk)\cdot a_2 L]\frac{E}{L^2}$$

$$= \left(\frac{ii}{AL^2} + \frac{jj}{3I_k} + \frac{kk}{3I_j}\right)\cdot f_1 L + \left(\frac{kj}{2I_j} - \frac{jk}{2I_k}\right)\cdot m_1, \tag{1d}$$

where all symbols are the conventional ones used by engineers except C which represents the nondimensional torsion constant and ii, jk, etc., which are dyads.

Now two special cases are discussed:

Case I. The end (1) is hinged.

Assuming that a couple m_1 is applied at the end (1) so as to produce a local rotation a_1. If their relation be given by

$$m_1 = \Phi\cdot a_1, \tag{2}$$

then Φ may be called the moment dyadic of this beam. Its value depends on the dimensions of the beam and the supporting condition of the other end. For example:

1. The end (2) is fixed ($a_2 = 0$, $d_2 = 0$). From Eq. (1), it gives

$$\Phi = \left(\frac{GI_i}{C}\,ii + 4EI_j jj + 4EI_k kk\right)\Big/ L, \tag{3a}$$

$$f_1 = -f_2 = \frac{-3}{2L}(kj - jk)\cdot m_1, \tag{3b}$$

and
$$m_2 = \eta\cdot m_1, \tag{3c}$$

where
$$\eta = -ii + \frac{jj}{2} + \frac{kk}{2}. \tag{4}$$

η may be called the carry-over dyadic factor.

2. The end (2) is also hinged ($m_2 = 0$, $d_2 = 0$). From Eq. (1), it gives

$$\Phi' = 3E(I_j jj + I_k kk)/L, \tag{5a}$$

$$f_1 = -f_2 = -(kj - jk)\cdot m_1/L, \tag{5b}$$

and
$$a_2 = -\eta\cdot a_1. \tag{5c}$$

Case II. The end (1) is slotted (i.e., a fictitious joint which can only produce a resisting moment to prevent any rotation but no resisting shear to prevent any displacement).

Assume that a force f_1 is applied at the end (1) so as to produce a local displacement d_1, while the displacement of the other end is d_2. If their relation be given by

$$f_1 = \Psi\cdot(d_1 - d_2), \tag{6}$$

then Ψ may be called the force dyadic of this beam. Its value also depends on the dimensions of the beam and the supporting condition of the other end. For example:

1. The end (2) is fixed or also slotted ($a_2 = 0$). From Eq. (1), it gives

$$m_1 = m_2 = \tfrac{1}{2}(kj - jk)\cdot f_1 L, \tag{7a}$$

$$f_2 = -f_1 \tag{7b}$$

and
$$\Psi = (AL^2 ii + 12I_k jj + 12I_j kk)\,\frac{E}{L^3}. \tag{7c}$$

Without sidesway, the approximate values will be

$$m_1 = m_2 = 0, \tag{8a}$$

and
$$\Psi = AEii/L. \tag{8b}$$

With sidesway, the approximate value for the reciprocal dyadic will be

$$\Psi^{-1} = \left(\frac{jj}{I_k} + \frac{kk}{I_j}\right)\frac{L^3}{12E}. \tag{9}$$

2. The end (2) is hinged ($d_2 = 0$, $m_2 = 0$). From Eq. (1), it gives

$$\Psi = (AL^2ii + 3I_kjj + 3I_jkk)\frac{E}{L^3}. \tag{10}$$

IV. AN EXTERNALLY HINGED RIGID JOINT.

The framework shown in Fig. 2 consists of an externally hinged rigid joint only, where a couple m_1 is applied so as to produce a rotation a_1 at that joint. It is required to analyze this framework.

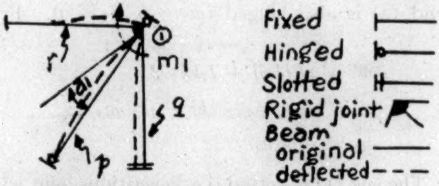


Fig. 2 A rigid joint

Assume that the moments exerted on the beams, p, q, $\cdots$ at the joint (1) are m_{1p}, m_{1q}, $\cdots$ and the corresponding moment dyadics are Φ_p, Φ_q, $\cdots$ respectively. From Eq. (2), it gives

$$m_{1p} = \Phi_p \cdot a_1, \qquad m_{1q} = \Phi_q \cdot a_1, \; \cdots,$$

$$m_1 = \Sigma m_{1p} = (\Sigma\Phi_p)\cdot a_1,$$

and therefore

$$a_1 = (\Sigma\Phi_p)^{-1}\cdot m_1. \tag{11a}$$

Putting

$$\phi_{1p} = \Phi_p\cdot(\Sigma\Phi_p)^{-1}, \qquad \phi_{1q} = \Phi_q\cdot(\Sigma\Phi_p)^{-1}, \; \cdots \tag{11b}$$

where ϕ_{1p}, ϕ_{1q}, $\cdots$ may be called the moment distribution dyadic factors (at that joint) of which the sum is surely an idemfactor, it gives

$$m_{1p} = \phi_{1p}\cdot m_1, \qquad m_{1q} = \phi_{1q}\cdot m_1, \; \cdots. \tag{11c}$$

Having obtained the values of a_1, m_{1p}, m_{1q}, etc., all beams may be easily analyzed by the aid of Eq. (1).

V. AN EXTERNALLY SLOTTED RIGID JOINT.

Consider the same framework shown in Fig. 2 except that the rigid joint (1) is externally slotted and that all other ends of the beams are either fixed or hinged ($d = 0$). Proceeding in the same manner as before, it gives

$$d_1 = (\Sigma\Psi_p)^{-1}\cdot f_1. \tag{12a}$$

Putting

$$\psi_{1p} = \Psi_p\cdot(\Sigma\Psi_p)^{-1}, \qquad \Psi_{1q} = \psi_q\cdot(\Sigma\Psi_q)^{-1}, \cdots \tag{12b}$$

where ψ_{1p}, ψ_{1q}, etc., may be called the force distribution dyadic factors (at that joint) of which the sum is also surely an idemfactor, it gives

$$f_{1p} = \psi_{1p}\cdot f_1, \qquad f_{1q} = \psi_{1q}\cdot f_1, \cdots. \tag{12c}$$

VI. EQUIVALENT LOAD SYSTEM.

If the load (which may be a force, a couple, or a combination of them) is applied at a point not at the ends, it may be replaced by two forces and two couples (Fig. 3) without influencing the stressed and strained condition of any other beam. The beam itself, to which the load is applied, needs a correction obtained by assuming both ends fixed. These forces and couples so suggested may be called the equivalent load system, and are given by the following formulae with secondary effect neglected:

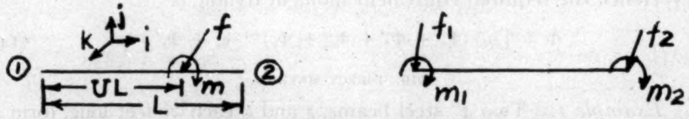


Fig. 3 Equivalent load System

$$f_1=(1-U)f+(U-U^2)[(1-2U)(jj+kk)\cdot f+6(kj-jk)\cdot m/L], \tag{13a}$$

$$f_2=f-f_1, \tag{13b}$$

$$m_1=(1-U)m+(U-U^2)[(1-U)(kj-jk)\cdot fL-3(jj+kk)\cdot m], \tag{13c}$$

and

$$m_2=m-m_1+(kj-jk)\cdot(Uf-f_2)L. \tag{13d}$$

For distributed loads the integration process is used.

VII. EQUIVALENT DYADICS.

The equivalent moment and force dyadics of a system of beams may be obtained as in the following illustrative example:

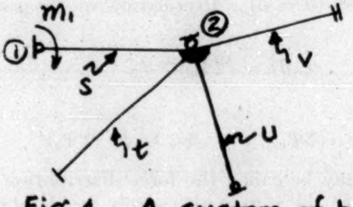


Fig. 4 A system of beams

Figure 4 shows a system of beams including an externally hinged one, acted on by a couple m_1 so as to produce a rotation a_1. From the above equations, it gives

$$a_1 = [\eta_s\cdot(\Phi_s + \Phi_t + \Phi_u + \Phi_v)^{-1}\cdot\eta_s + \Phi_s']^{-1}\cdot m,$$

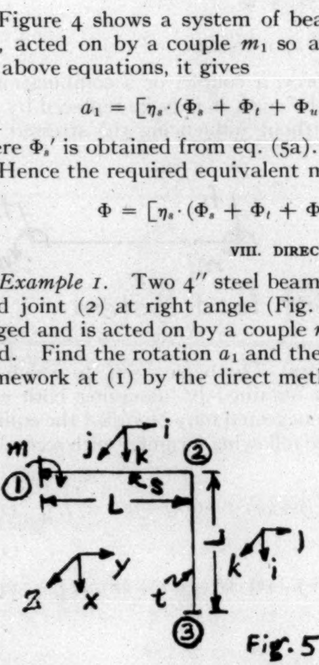
where Φ_s' is obtained from eq. (5a).

Hence the required equivalent moment dyadic is

$$\Phi = [\eta_s\cdot(\Phi_s + \Phi_t + \Phi_u + \Phi_v)^{-1}\cdot\eta_s + \Phi_s']^{-1}. \qquad (14)$$

VIII. DIRECT METHOD.

Example 1. Two 4″ steel beams, s and t, each 20 feet long, form a rigid joint (2) at right angle (Fig. 5). The end (1) of the beam s is hinged and is acted on by a couple m, while the end (3) of the beam t is fixed. Find the rotation a_1 and the equivalent moment dyadics of this framework at (1) by the direct method.



Beam	i	j	k
s	y	z	x
t	x	y	z

Fig. 5 Example I

Solution: (*First step*)—Tabulate the unit vectors i, j, k of each beam in terms of three standard orthogonal unit vectors x, y, and z (Fig. 5).

(*Second step*)—Determine the number of unknown vectors.

In this problem, the known vectors are:

$$m_{1s} = m, \qquad d_1 = 0, \qquad d_3 = 0, \qquad a_3 = 0.$$

The unknown vectors are:

$$f_{1_s},\ f_{2_s},\ f_{2_t},\ f_{3_t},\ m_{2_s},\ m_{2_t},\ m_{3_t},\ a_1,\ a_2,\ d_2.$$

(*Third step*)—For the circular steel beams,

$$C = 1, \qquad I_i/2 = I_j = I_k = I, \qquad \text{say,} \qquad G/E = 0.4. \tag{15}$$

Substituting the above values in Eq. (1), it gives

$$f_{2_s} = -f_{1_s}, \tag{16a}$$

$$m_{2_s} = -m_{1_s} + (xz - zx)\cdot f_{1_s}L, \tag{16b}$$

$$(a_1 - a_2)EI/L = (zx - xz)\cdot f_{1_s}L/2 + (1.25yy + xx + zz)\cdot m_{1_s}, \tag{16c}$$

$$[-d_2 - (xz - zx)\cdot a_2L]\frac{EI}{L^2} = (xx + zz)\cdot\frac{f_{1_s}L}{3} + (xz - zx)\cdot\frac{m_{1_s}}{2}, \tag{16d}$$

$$f_{3_t} = -f_{2_t}, \tag{16e}$$

$$m_{3_t} = -m_{2_t} + (zy - yz)\cdot f_{2_t}L, \tag{16f}$$

$$a_2EI/L = (yz - zy)\cdot f_{2_t}\frac{L}{2} + (1.25xx + yy + zz)\cdot m_{2_t}, \tag{16g}$$

$$d_2\frac{EI}{L^2} = (yy + zz)\cdot f_{2_t}\frac{L}{3} + (zy - yz)\cdot\frac{m_{2_t}}{2}. \tag{16h}$$

Take the rigid joint (2) as a free body,

$$f_{2_s} + f_{2_t} = 0, \tag{16i}$$

and

$$m_{2_s} + m_{2_t} = 0. \tag{16j}$$

A total of ten independent equations is sufficient to solve for the ten unknown vectors. The general proof may also be sought by resolving each vector into three components. Thus the number of unknowns are increased to three times with equal number of linear scalar equations.

(*Fourth step*)—Solve these equations.

Substituting Eqs. (16g), (16h) into (16d) and eliminating f_{2_t}, m_{2_t}, it gives

$$(16xx - 6xy - 6yx + 4yy + 23zz)\cdot f_{1_s}L = (6xz - 6zy + 21zx - 16xz)\cdot m$$

whence

$$f_{1_s} = -f_{2_s} = f_{2_t} = -f_{3_t} = \left(\frac{21zx - 6zy}{23} - \frac{9xz - 3yz}{7}\right)\cdot\frac{m}{L}. \tag{16k}$$

From Eq. (16c)

$$a_1 = \left(\frac{60xx + 42xy + 42yx + 195yy}{92} + \frac{2zz}{7}\right)\frac{mL}{EI}.$$

Putting $L = 20$ and solving for the equivalent moment dyadic of this framework at (1), it gives

$$\Phi = (0.090xx - 0.020xy - 0.020yx + 0.028yy + 0.175zz)EI. \qquad (16l)$$

IX. ITERATION METHOD.

Example 2. Fig. 6 represents a framework with two rigid joints and five 4″ steel beams. A force $400(y - z)$ is applied at the midpoint of the beam q. It is required to find the displacement and rotation of joint (1) and the reactions at the ends of beams q by iteration method.

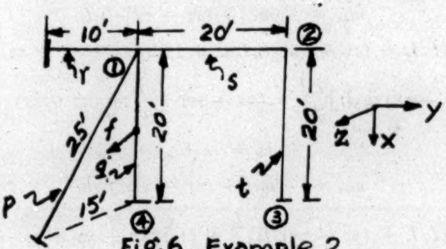


Fig. 6 Example 2

Solution: (*First step*)—Tabulate the unit vectors i, j, k of the beams as in Example 1.

Beam	i	j	k	L, ft.
p	$0.8 + 0.6z$	$0.6x + 0.8z$	y	25
q	x	y	z	20
r	$-y$	x	z	10
s	y	z	x	20
t	x	y	z	20

(*Second step*)—Find the equivalent load system if necessary. From Eq. (13), it gives

$$f_1 = f_2 = 200z - 200y,$$

and

$$m_1 = m_2 = 1000(y + z).$$

(*Third step*)—Determine whether there is sidesway or not.

By observation it is seen that rigid joint (2) has sidesway while rigid joint (1) has not.

(*Fourth step*)—Determine the distribution dyadic factors and also the equivalent dyadics if necessary.

1. Consider the joint (1) as hinged. It gives

$$\Phi_p = (0.2i_pi_p + j_pj_p + k_pk_p)4EI/L_p \qquad \text{from Eq. (3a), (15),}$$

$$= (0.078xx - 0.061xz - 0.061zx + 0.114zz + 0.160yy)EI,$$

$$\Phi_q = (0.04xx + 0.20yy + 0.20zz)EI,$$

$$\Phi_r = (0.08yy + 0.40xx + 0.40zz)EI,$$

and

$$\Phi_{s,t} = (0.09xx - 0.02xy - 0.02yx + 0.028yy + 0.175zz)EI,$$

from Eq. (16l).

The reciprocal of their sum is

$$(\Sigma\Phi)^{-1} = (1.66xx + 0.07xy + 0.07yx + 0.12xz + 0.12zx + 2.14yy + 1.13zz)/EI.$$

Substituting into Eq. (11b), the moment distribution factors are

$$\phi_{1p} = 0.123xx + 0.005xy - 0.061xz + 0.011yx + 0.342yy - 0.090zx + 0.122zz,$$

$$\phi_{1q} = 0.066xx + 0.003xy + 0.004xz + 0.014yx + 0.428yy + 0.023zx + 0.227zz,$$

$$\phi_{1r} = 0.663xx + 0.028xy + 0.047xz + 0.006yx + 0.171yy + 0.047zx + 0.453zz,$$

and $\phi_{s,t} = 0.148xx - 0.036xy + 0.010xz - 0.031yx + 0.059yy + 0.020zx + 0.198zz,$

of which the sum is $xx + yy + zz$. (Check.)

2. Consider the joint (1) as slotted. Since it has no sidesway, it is not necessary to distribute the unbalanced force to joint (2). From Eq. (8b), it gives

$$\Psi_p = i_p i_p EA/L_p$$
$$= (0.0256xx + 0.0192xz + 0.0192zx + 0.0144zz)EA,$$

$$\Psi_q = 0.05xxEA,$$

and $\Psi_r = 0.10yyEA.$

The reciprocal of their sum is

$$(\Sigma\Psi)^{-1} = (20xx - 26.7xz - 26.7zx + 105zz + 10yy)/EA.$$

Substituting into Eq. (12b), the force distribution factors are

$$\psi_{1p} = zz + 1.33xz,$$

$$\psi_{1q} = xx - 1.33xz,$$

and $\psi_{1r} = yy,$

of which the sum is $xx + yy + zz$. (Check.)

(*Fifth step*)—Distribute the unbalanced moments and forces in succession until the required precision is obtained.

1. Consider the joint (1) as externally hinged and distribute m_1 to the corresponding beams:

$$m_{1_p} = -\ 56x + 342y + 122z,$$

$$m_{1_q} = 7x + 428y + 227z,$$

$$m_{1_r} = 75x + 171y + 453z,$$

and $$m_{1_s} = -\ 26x + 594y + 198z.$$

From Eq. (3b), it gives

$$f_{1_p} = 12x + 8y - 16z,$$

$$f_{1_q} = 17y - 32z,$$

$$f_{1_r} = 68x - 11z,$$

and $$f_{1_s} = -\ 13x - 4y - 2z, \qquad \text{from Eq. (16k).}$$

Hence the total reaction at the "hinged" joint is $67x + 21y - 61z$. But actually this joint is free and is under a load $200(z - y)$. The unbalanced force is

$$f_1^* = -\ 67x - 221y + 261z.$$

2. Consider the joint (1) as externally slotted and distribute f_1^* to the corresponding beams:

$$f_{1_p} = 347x + 261z,$$

$$f_{1_q} = -\ 414x,$$

and $$f_{1_r} = -\ 221y.$$

All joints are now in equilibrium.

(*Sixth step*)—Superpose the results obtained in 1 and 2:

$$f_{1_q} = -\ f_{4_q} = -\ 414x + 17y - 32z,$$

$$m_{1_q} = 7x + 428y + 227z,$$

and $$m_{4_q} = \eta_q \cdot m_{1_q} = -\ 7x + 214y + 114z.$$

The true values are obtained by correcting for the equivalent load system:

$$f_{1_q} = -\ 414x + 217y - 232z,$$

$$f_{4_q} = 414x + 183y - 168z,$$

$$m_{1_q} = 7x - 572y - 773z,$$

and $$m_{4_q} = -\ 7x + 1214y + 1114z.$$

Also $a_1 = (\Sigma\Phi)^{-1}\cdot m_1 = (170x + 2140y + 1130z)/EI$ radians,

and $d_1 = (\Sigma\Psi)^{-1}\cdot f_1^* = (-\ 8300x - 2040y + 29200z)/EA$ feet.

THE ORIGIN OF INTERCHANGEABLE PARTS.

BY

THOMAS COULSON,

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Through the generosity of the late Ralph H. North, The Franklin Institute Museum received a handsome collection of the pistols and rifles made during the years 1799 and 1852 by his great-grandfather, Simeon North, the first official pistol maker to the United States. The case of weapons is surrounded by an interest which goes far beyond that of the arms collector, for some of the items are milestones along the early path of progress made in manufacture of interchangeable parts. Controversy will continue to rage around the relative claims of Simeon North and Eli Whitney to be granted the honor of being the originator of the system, which is the essence of mass production. While no pretence is made to weigh the claims of the two pioneers, this paper attempts to set forth more fully than has been done before the circumstances of the establishment of that system.

It was not entirely by chance that the manufacture of interchangeable parts had its genesis in the United States, nor that the pioneers were the nation's gunsmiths. The system suggests itself in operations which require the repetition of a uniform series of more or less simple movements. Such repetitive production was repugnant to the American worker of the eighteenth century, who was accustomed to more varied pursuits and who was temperamentally too impatient to follow a routine. A secondary influence in the adoption of devices for the replacement of handiwork was the scarcity of skilled labor in the country and the high wages demanded by those who had acquired a skill in mechanical craftsmanship.

Yet, in spite of these forces, there was no stimulation to the invention of the necessary machinery, except where the demand for the product was large enough to justify its installation. There were relatively few uses for articles made of metal. Aside from castings, the only market for metal products of uniform shape was in common tools, such as axes, scythes, etc. The most elementary stage in the mechanical production of uniform metal parts was entered when a machine was invented, shortly before 1790, which automatically cut plates into nails. The next stage was the development by the gunsmiths, and it is a singular coincidence that, of all the typical products now produced under the system of interchangeable parts, weapons and clocks are the only ones that ante-date the system itself.

Although the system is inseparably associated with this country, and is called the "American System" abroad, the first suggestions for its use came from France. At least two early attempts to manufacture muskets from interchangeable parts were made in France during the eighteenth century. The first, in 1717, is practically unknown, and the second might have suffered a similar oblivion had it not attracted attention in an unexpected quarter. During the time he was Minister to France, Thomas Jefferson wrote to John Jay, under the date August 30th, 1785, a letter which contains the following passage:

> "An improvement is made here in the construction of muskets, which it may be interesting to Congress to know, should they at any time propose to procure any. It consists in the making every part of them so exactly alike, that what belongs to any one, may be used for every other musket in the magazine. . . . Supposing it might be useful in the United States, I went to the workman. He presented me the parts of fifty locks taken to pieces, and arranged in compartments. I put several together myself, taking pieces at hazard as they came to hand, and they fitted in the most perfect manner. The advantages of this, when arms need repair, are evident. He effects it by tools of his own contrivance, which, at the same time, abridge the work, so that he thinks he will be able to furnish the musket two livres cheaper than the common price."[1]

The name of the mechanic was revealed in a later letter to be Le Blanc, and he extended his system to the standardization of manufacturing the barrel, mounting, and stock. Jefferson was much impressed by Le Blanc's achievement, for he brought it to the attention of the Governor of Virginia in another letter, and years later he recalls the incident in a letter to James Monroe, in which he wrote: "I endeavored to get the United States to bring him over, which he was ready for on moderate terms. I failed and I do not know what became of him."[2]

The indifference of the home authorities to Jefferson's suggestion can only be attributed to the incurable reluctance of the American people to make advance preparation for an outbreak of hostilities. Jefferson was a man of many parts. He was a statesman of superior qualities who demonstrated in these letters a realization of the official responsibility to have at hand the adequate means of implementing national policies. He also possessed sufficient mechanical ability to perceive that where a gun was made of parts, each made by hand and eye, without gauges, and fitted to its neighbors, the loss or deformation of a single part rendered the gun useless for a considerable time. This may not have been a grave matter when each individual was supposed to furnish his own weapons, but when a national army was in question

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[1] The Writings of Thomas Jefferson, edited by H. A. Washington, New York, 1853, vol. i, p. 411.

[2] Writings of Thomas Jefferson, edited by P. L. Ford, New York, 1887, vol. viii, p. 101.

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the matter assumed a very serious aspect. In 1812, the British government, on the authority of Eli Whitney, had 200,000 muskets awaiting repair of some defects,[3] so that the desire for an interchangeable parts system of production must have been acutely felt. It is perhaps necessary to point out how exasperating the dissimilarity of weapons must have been to George Washington, whose men had to carry individual bullet moulds because of variations in the calibers of their muskets.

If the authorities were unwilling to employ Le Blanc on Jefferson's recommendation, they certainly displayed no reluctance to adopt his system when the need arose for the expansion of gun-making. Because of the threat of impending war with France, the Congress, in 1798, passed an act appropriating $100,000 for the purchase of arms and ammunition. Two of the contracts recorded in the fulfillment of this legislative act are of the utmost importance in the origin of manufacture of interchangeable parts.

One of these contracts went to Eli Whitney, who had already invented the cotton gin, which was to have such a profound economic influence upon our civilization. Unfortunately, the unsatisfactory condition of the patent situation offered him no protection and he lost, rather than gained, money as the result of his revolutionary invention. In order to find a means of livelihood he had decided to enter the gunsmith's field. Having received his contract for 10,000 muskets (one quarter of those required) he built a small plant at Whitneyville, near New Haven, Conn., which was operated by water power. Two years were consumed in building the plant and in furnishing it with the necessary machinery. Just what that machinery was may be conjectured from a letter he wrote to the Secretary of the Treasury in 1798 soliciting the contract. He wrote:

> "I should like to undertake the manufacture of ten to fifteen thousand stand of arms. I am persuaded that machinery moved by water, adapted to this business would greatly diminish the labor and greatly facilitate the manufacture of this article. Machines for forging, rolling, floating, boring, grinding, polishing, etc., may all be made use of to advantage.[4]

The second contract of significance was awarded to Simeon North, a practicing gunsmith of Berlin, Conn., which was for 500 horse pistols, a number which was subsequently raised to 1,500 two years later. North's entire contract was completed and the pistols delivered before Whitney had turned out a musket. In view of the controversy which arose over priority in the manufacture of interchangeable parts, it should be mentioned that none of these early contracts makes mention of their use. It is, however, apparent that North was early in this field, for he describes the subdivision of labor in a letter written to the Secretary of the Navy, written on November 7th, 1808, in which he writes:

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[3] Letter quoted in Blake, History of Hamden, Conn., New Haven, 1888, p. 133.

[4] New Haven Colony Historical Society Papers, vol. v, p. 117.

> "To make my contract for pistols advantageous to the United States and to myself I must go to a great proportion of the expense before I deliver any pistols. I find that by confining a workman to one particular limb of the pistol until he has made two thousand, I save at least one quarter of his labor, to what I should provided I finish^{d}. them by small quantities: and the work will be as much better as it is quicker made.
>
> "To proceed in this way I must purchase the most of my Stock and Bestow a great proportion of the labour upon it before I can finish a pistol . . . I have seventeen thousand screws and other parts of the pistols now forg^{d}. and many parts nearly finished and the business is going on pretty lively." [5]

It has been stated that this is the first documentary proof that the system of manufacturing interchangeable parts had been placed in operation. But, it must be pointed out that Whitney claimed to have been performing this process as early as 1800, when he first began work on muskets. This claim rests upon a letter which he wrote in the year 1812, and in which he states:

> "The subscriber begs leave further to remark that he has for the last 12 years been engaged in manufacturing muskets; that he has now the most respectable private establishment in the United States for carrying on this important branch of business. That this establishment was commenced and has been carried on upon a plan which is unknown in Europe, and the great leading object of which is to substitute and correct effective operations of machinery for that skill of the artist which is acquired only by long practice and experience; a species of skill which is not possessed in this country to any considerable extent." [6]

This claim is substantiated by Captain Decius Wadsworth, who wrote to the Secretary of the Treasury in 1800 in the following terms:

> "Where the different parts of the lock are each formed and fashioned successively by a proper machine, and by the same hand, they will be found to differ so insensibly that the similar parts of different locks may be mutually substituted. The extending of this principle to all parts of the musket has been a favorite idea with Mr. Whitney from the beginning." [7]

Finally, in Jefferson's letter to Monroe, already quoted, there appears additional corroboration, for he says in speaking of Whitney, "He has invented moulds and machines for making all the pieces of his locks so exactly equal that to take 100 locks to pieces and mingle their

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[5] North, S. N. D., and R. H. Simeon North: first official pistol maker of the United States, Concord, 1913, p. 64.

[6] New Haven Colony Historical Society Papers, vol. v, p. 122.

[7] Blake, p. 296.

THE
SIMEON NORTH
COLLECTION OF GUNS
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parts and the 100 locks may be put together by taking the pieces which come to hand."

There can be little doubt that Whitney experienced no small difficulty in completing his first contract. He and fourteen other contractors were notified by the Purveyor of Supplies that, as the stipulated time for the delivery of the muskets had expired, they were granted ten weeks in which to comply with its terms or suffer their contracts to be cancelled. Whitney was actually engaged over a period of eight years in fulfilling his contract for 10,000 muskets. The delay was not exclusively due to the difficulties he was encountering in the designing and making of machines to accomplish the various tasks, because, in 1801, he saw the French Model 1777 musket and was so impressed by its superiority over the Model 1763, which had been contracted for, that he suggested changes of fabrication that would improve it. His suggestions were adopted by the Ordnance officers, and he finished the balance of his 1798 contract with this improved model, which undoubtedly implied a certain amount of retooling.

The astonishing thing about his solicitation of a contract to manufacture muskets is not that he should have contemplated entering the field of the gunsmith, in which he was wholly inexperienced, but that he should have ventured into this strange craft with a system of manufacture that was entirely novel.

It is to be regretted that Whitney's contribution to the introduction of interchangeable parts has not been so fully and so dutifully described as was Simeon North's share in the achievement. There seems no doubt that he was confronted with numerous obstacles which tried his patience and tested his ingenuity. Nor does it appear that the system he had adopted enabled him to manufacture at reduced cost in comparison with competitors. His reputation as a mechanic was too firmly established, however, to permit the authorities to dispense with his services when his deliveries and his price were not quite up to standard. In the Ordnance Department's correspondence there is a revealing letter written by Callender Irvine, the Purveyor of Supplies, who was trying to reduce to order the chaos created by the private contractor system. Writing to the Secretary of War on January 12th, 1814, he declares:

> "Tis, true a contract was entered into with Eli Whitney dated 18th of July 1812 for 15,000 Muskets with Bayonets and Ramrods complete at $13 Dollars per stand but from the specimen I have seen of the muskets he intended to deliver, not being any better than those delivered at $10.75/100 Dollars and his refusal to have them made superior to those; as well as from his not having delivered any Arms altho his contract required him to deliver 500 stands on or before 1st of May 1813 he has been notified that his contract is at an end and directed to return the amount advanced to him.[8]

However, the Secretary of War had a better appreciation of Whitney's ability and methods, and declined to permit the cancellation of the contract. This did not dispel Irvine's apprehensions of Whitney for, when the manufacturer notified the Purveyor that he had 500 muskets ready for inspection in the following year, Irvine was disturbed by the vagueness of Whitney's contract and directed the Inspector of Arms to select three of the muskets, "let them be as nearly alike as may be in all their parts as they are intended to govern in Inspection of Mr. Whitney's future deliveries."

The vagueness of Whitney's contract (and it was vague) was certainly remedied in subsequent contracts, and it is through Irvine's

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[8] Hicks, Major J. E., Notes on United States Ordnance, Mount Vernon, N. Y., 1940, vol. ii, p. 45.

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laudable intention of drawing up a more satisfactory contract that we have the first mention of the weapon being made from interchangeable parts. As we have shown from various selections from the correspondence of the times, Whitney and North were both engaged in this system of manufacture. During the time he was Purveyor, Tench Coxe had encouraged it, but his successor, Callender Irvine, had small respect for Coxe and none whatever for the men to whom he awarded contracts. He was continually at war with the private manufacturers, hurling threats of suits and cancellations in his endeavors to obtain a satisfactory discharge of contractual obligations. He, too, must have realized the great advantages in the new system, for within a year of assuming office Irvine found a French musket which pleased his exacting fancy, and having secured the War Departments approval of the model, he used it as the standard for the next contracts. In a letter to his four deputy commissioners of supply regarding the manufacture of the muskets, he says: "It is intended that the locks, bands, plates, and screws of one Musket may be fitted to any other musket of 100,000, all the component parts being made precisely on the same Models." [9]

Accordingly, North's contract in 1813 contains a clause which extends the application of interchangeable parts to the manufacture of pistols, so that the system appears now to have met with general acceptance. The same clause stipulates that, with each 100 pistols delivered, the manufacturer was to furnish a specified number of spares for those parts which were most subject to fracture or deformation.

However, the idea of specialization had not entirely been obliterated from the official mind. In order to obtain a more reliable water supply for his power, and to extend his manufacturing accommodation so that he could undertake the larger orders he was receiving from the Government, North had moved into a new building at Middletown, upon which he had spent a considerable sum of money. It would seem that the pistol contracts were insufficient to maintain the large staff of workmen he assembled there, because he was impelled to solicit a contract for muskets or rifles. Decius Wadsworth (now a Colonel of Ordnance), who had enthusiastically welcomed Whitney's system of interchangeable parts in an industry where Whitney had no experience whatever, now doubted the wisdom of confiding the making of rifles to a man who had specialized in making pistols. However, the Colonel's fears proved to be unfounded when North was awarded a contract in 1823 and demonstrated his proficiency by fulfilling its terms in one year under the stipulated time, which was something of a rarity among private arms contractors, who were always behind in their deliveries.

It is not inconceivable that this proof of plant efficiency induced the Government to grant him other contracts against the advice of one official armorer. This was in 1828, when the new Hall Rifle went into production. The wording of this contract is important since it marks a further step in the progress of the manufacture of interchangeable parts. After the now commonplace clause providing that all the component parts shall be interchangeable, the contract adds: "And also that the component parts may be exchanged in a similar manner, with the rifles made, or making, at the National Armory. The said exchange to be made without impairing in the least the efficiency or perfection of the Arms, which are thus composed of exchanging parts."

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[9] Hicks, vol. i, p. 44.

Captain John H. Hall, who was then assistant armorer at Harper's Ferry national armory, did not like this provision in a private contractor's arrangements, and prophesied all manner of evils would arise from it in making the rifle he had invented. Hall was a disciple of Whitney and North in the manufacture of interchangeable parts, for he had resolved to institute the system for the manufacture of his rifle. In some extraordinary manner, he has become credited in some quarters as the originator of the system. He did not even introduce the system into the national armories. In the year 1824, one hundred rifles had been brought together from the different armories and makers, broken down, and re-assembled at random.[10]

However, it is obvious that Hall contributed to the progress of the system, for he built special machines and tools, several of which he patented. However, his methods do not appear to have been as efficient as those of Simeon North. For, in the year 1836, the cost of making a Hall Rifle at Harper's Ferry was $21.13, whereas North was paid only $17.20 for the same rifle.

By this time, it may be acknowledged, the practice of manufacturing interchangeable parts had passed from the experimental stage and was universally accepted, in the arms industry, at least. It is difficult in our day to realize the immensity of the obstacles which had to be overcome by those pioneers who had nothing but their imagination to guide them. Everything was lacking—shops, materials, mechanics. Blacksmiths and an occasional coppersmith were the only workmen who could be engaged to make a specific tool, and they were likely to produce something with a poor edge and worse temper. Nor should we overlook the amazing isolation of the specialized craftsmen, probably the outcome of the guilds for preserving the "mystery" of manufacture. This isolation is very important, for its existence contributes substantially to the magnitude of the task confronting North and Whitney. For example, clockmakers had been able to make an instrument of such intricacy that it not only indicated accurately the passage of hours, minutes, and seconds, but also the days of the month, the phases of the moon, and the movements of the known planets. As an artistic concession to this accumulation of scientific craft, they not infrequently introduced mechanism for playing musical selections and for controlling the actions of a group of marionettes. Yet, at the time these accomplishments were becoming relatively common, James Watt could not find anyone who could bore a cylinder sufficiently accurately to make a piston steam-tight.

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[10] Newcomen Society Transactions, vol. xvii, 1936, p. 170.

When Whitney and North began to make muskets and pistols for the Government, there were very few machine tools in existence and few mechanics to whom they could turn for assistance. Maudsley was working upon the slide lathe in England, and there appears to have been some contemporary invention along similar lines in this country. Sylvanus Brown of Pawtucket is said to have invented a slide rest in 1791, and to have used it for cutting wrought iron screws for sperm oil presses. Jigs, too, had tentatively made their appearance in the textile industry. But this left the pioneers Whitney and North with a vast field of invention to cover before they could begin production.

Priority of invention is likely to remain in dispute by their supporters, but it seems improbable that the two men, living and working within twenty miles of each other, engaged in closely related pursuits, competing for the same contracts, and working through the same Government officials, should be unacquainted with what was going on in each other's plant. It would be wise to refrain from advancing too urgently the efforts to differentiate between the claims of the two men.

It would be an overestimate in the genesis of the system to say that either Whitney or North in the beginning surpassed a general concept of the problem of the manufacture of interchangeable parts. The process must have undergone much development and revision at their hands, and did not reach its full primary accomplishment much before 1830. But the achievement in that short time of thirty years is remarkable, not only in invention but in overcoming the inevitable inertia, opposition, and scepticism which obstructs all revolutionary proposals.

Colonel North never filed a patent, not even for the improvement of the firearms he was making, but his family have maintained the tradition, which may be true, that the filing jig was invented by his son Selah. They claim further [11] that the first milling machine was made and used in the North factory. Whitney constructed a milling machine in 1818, which is now treasured by Yale University, but the milling of irregular parts did not come until after 1840. During the years 1817–22 there came from various sources the introduction of forging in hand dies, barrel turning by machinery, and the automatic lathe for gunstocks. Receiving gauges were used in North's plant in Middletown after 1829, and Hall had already begun to use the drop hammer with dies at Harper's Ferry in 1827.

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[11] North, p. 84.

Thus, the elimination of handwork and the substitution of semi-automatic machinery was firmly established in the arms industry before the middle of the century. A contemporary journal [12] declares that 100 different machines were employed in the armories of the United States. These machines are described as self-acting and so automatic that several units could be supervised by a single workman.

The security afforded by governmental contracts and the willingness of the authorities to subsidize private contractors, undoubtedly contributed greatly to the promotion of the manufacture in the arms industry, but this detracts in no way from the abilities of the two pioneers, Eli Whitney and Simeon North. They pointed the way, they laid the road which succeeding generations were to tread. Others were not slow to follow their example. As soon as it became possible to substitute brass for wood in clock parts, the clock industry underwent a revolution by the introduction of interchangeable parts; and new industries which sprang up, like the manufacture of sewing machines, the harvester, and the typewriter, all adopted the system from their inception.

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[12] Farmer and Mechanic, vol. ii, Sept. 14, 1848, p. 440.

REPORT ON THE EDUCATIONAL ACTIVITIES OF THE FRANKLIN INSTITUTE.

BY

ARMAND N. SPITZ,
Director of Museum Education, The Franklin Institute.

> ". . . *Go! mount where Science guides,*
> *Go measure Earth, weigh Air, and state the Tides;*
> *Shew by what Laws the wand'ring Planets stray,*
> *Correct old Time, and teach the Sun his Way.*"
> —B. Franklin

He wrote these words almost two centuries ago . . . in 1745. Just a little more than seven years ago Dr. Henry Butler Allen quoted them in his monthly Director's Editorial in *The Institute News*, with the following suggestion:

"Just insert the words 'To The Franklin Institute' in place of the periods at the beginning of this verse."

Of all men who would have reveled in the push-button method of teaching the fundamental principles of science, Benjamin Franklin would have been the most enthusiastic, for he passionately devoted his every effort to the popularization and simplification of scientific theories. He knew what he wanted, educationally, and he knew how to achieve his end. He scorned the round-about descriptions of scientific phenomena, and used direct language. At the end of a discussion of one of his meteorological observations he said:

"If my hypothesis is not the truth itself it is at least as naked, for I have not, with some of our learned moderns disguised my nonsense in Greek, clothed it in algebra nor adorned it with fluxions. You have it *in puris naturalibus*." At another time he demonstrated his realization that a graphic picture is far more helpful in conveying an idea than almost an unlimited number of words. "Drawing is a kind of universal language," he wrote, in outlining his ideas for an educational project, "understood by all nations. A man may often express his ideas, even to his own countrymen, more clearly with a lead pencil or a bit of chalk than with his tongue. And many can understand a figure that do not comprehend a description in words, though ever so properly chosen." He urged students to read histories of nature and commerce, "of the invention of arts, rise of manufactures, progress of trade . . . ." all of which would lead to a curiosity about mechanics, "that art by which weak men perform such wonders, labour is saved, manufactures expedited, etc." In his suggestions for the equipment of such an academy, he urged that there be "globes, some mathematical instruments, an apparatus for experiments in natural philosophy and for mechanics; prints of all kinds, prospects, buildings, machines, etc."

PIONEER OF VISUAL EDUCATION.

He realized that the new ideas of science had to be presented to the public in a novel form, in a dramatic presentation which would command attention. His friend, Ebenezer Kinnersley, a clergyman with no pastorate but with a flair for the dramatic, was deeply interested in Franklin's electrical experiments, and was, himself, experimenting in the same field. Franklin prepared a series of electrical demonstrations, equipped Kinnersley with the necessary apparatus, and sent him out into the provinces to show the people of the country-side the marvels of electricity. The advertising handbill which Franklin wrote ended:

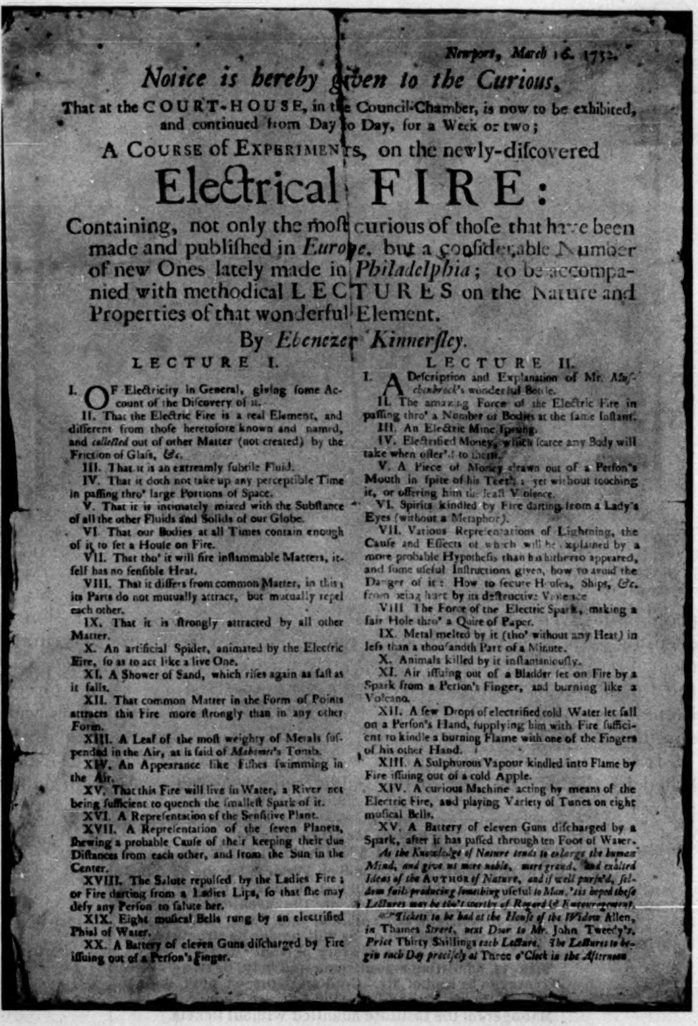
"As the Knowledge of Nations tends to enlarge the human Mind, and give us more noble, more grand, and exalted ideas of the AUTHOR of Nature, and if well persu'd, seldom fails producing something useful to Man, 'tis hoped these Lectures may be tho't worthy of Regard & Encouragement."

Certainly this project, if no other the man ever undertook in his life, stamped him as one of the pioneers in what is today called audio-visual education, and gave the Institute which was later to bear his name an impressive example of aggressive methods in carrying science to the public.

THE BIRTH OF THE INSTITUTE'S EDUCATIONAL PROGRAM.

It is now six score years since The Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts was first brought into being by a group of men who felt that there was an intense need for education, particularly in the sciences. The mechanical age was here. Men had little training, and there were few facilities for obtaining it. One of the men who felt this need most deeply was twenty-two year-old Samuel Vaughan Merrick. He wanted to study, but could find no facilities for doing so. He enlisted the support of William H. Keating, a young professor of chemistry at the University of Pennsylvania. An overflow meeting was held at the County Court House. It was decided that the program of the proposed Institute would include "the establishment of popular lectures, the formation of a cabinet of models and minerals, a library, and offering premiums on all useful improvements in the mechanic arts."

The first lecture was presented the month after the Institute was formally organized, and these lectures have been continuing without interruption ever since. In October, 1824 a school of architectural and mechanical drawing was organized. Two years later a high school was opened, the first school of its sort in the city. The need for classes by



Newport, March 16. 1752.

Notice is hereby given to the Curious,

That at the COURT-HOUSE, in the Council-Chamber, is now to be exhibited,
and continued from Day to Day, for a Week or two;

A COURSE of EXPERIMENTS, on the newly-diſcovered

Electrical FIRE:

Containing, not only the moſt curious of thoſe that have been made and publiſhed in *Europe*, but a conſiderable Number of new Ones lately made in *Philadelphia*; to be accompanied with methodical LECTURES on the Nature and Properties of that wonderful Element.

By *Ebenezer Kinnerſley*.

LECTURE I.

I. OF Electricity in General, giving ſome Account of the Diſcovery of it.

II. That the Electric Fire is a real Element, and different from thoſe heretofore known and named, and *collected* out of other Matter (not created) by the Friction of Glaſs, *&c.*

III. That it is an extreamly ſubtile Fluid.

IV. That it doth not take up any perceptible Time in paſſing thro' large Portions of Space.

V. That it is intimately mixed with the Subſtance of all the other Fluids and Solids of our Globe.

VI. That our Bodies at all Times contain enough of it to ſet a Houſe on Fire.

VII. That tho' it will fire inflammable Matters, itſelf has no ſenſible Heat.

VIII. That it differs from common Matter, in this; its Parts do not mutually attract, but mutually repel each other.

IX. That it is ſtrongly attracted by all other Matter.

X. An artificial Spider, animated by the Electric Fire, ſo as to act like a live One.

XI. A Shower of Sand, which riſes again as faſt as it falls.

XII. That common Matter in the Form of Points attracts this Fire more ſtrongly than in any other Form.

XIII. A Leaf of the moſt weighty of Metals ſuſpended in the Air, as is ſaid of *Mahomet*'s Tomb.

XIV. An Appearance like Fiſhes ſwimming in the Air.

XV. That this Fire will live in Water, a River not being ſufficient to quench the ſmalleſt Spark of it.

XVI. A Repreſentation of the Senſitive Plant.

XVII. A Repreſentation of the ſeven Planets, ſhewing a probable Cauſe of their keeping their due Diſtances from each other, and from the Sun in the Center.

XVIII. The Salute repulſed by the Ladies Fire; or Fire darting from a Ladies Lips, ſo that ſhe may defy any Perſon to ſalute her.

XIX. Eight muſical Bells rung by an electrified Phial of Water.

XX. A Battery of eleven Guns diſcharged by Fire iſſuing out of a Perſon's Finger.

LECTURE II.

I. A Deſcription and Explanation of Mr. *Muſchenbroeck*'s wonderful Bottle.

II. The amazing Force of the Electric Fire in paſſing thro' a Number of Bodies at the ſame Inſtant.

III. An Electric Mine ſprung.

IV. Electrified Money, which ſcarce any Body will take when offer'd to them.

V. A Piece of Money drawn out of a Perſon's Mouth in ſpite of his Teeth; yet without touching it, or offering him the leaſt Violence.

VI. Spirits kindled by Fire darting from a Lady's Eyes (without a Metaphor).

VII. Various Repreſentations of Lightning, the Cauſe and Effects of which will be explained by a more probable Hypotheſis than has hitherto appeared, and ſome uſeful Inſtructions given, how to avoid the Danger of it: How to ſecure Houſes, Ships, *&c.* from being hurt by its deſtructive Violence.

VIII. The Force of the Electric Spark, making a fair Hole thro' a Quire of Paper.

IX. Metal melted by it (tho' without any Heat) in leſs than a thouſandth Part of a Minute.

X. Animals killed by it inſtantaniouſly.

XI. Air iſſuing out of a Bladder ſet on Fire by a Spark from a Perſon's Finger, and burning like a Volcano.

XII. A few Drops of electrified cold Water let fall on a Perſon's Hand, ſupplying him with Fire ſufficient to kindle a burning Flame with one of the Fingers of his other Hand.

XIII. A Sulphurous Vapour kindled into Flame by Fire iſſuing out of a cold Apple.

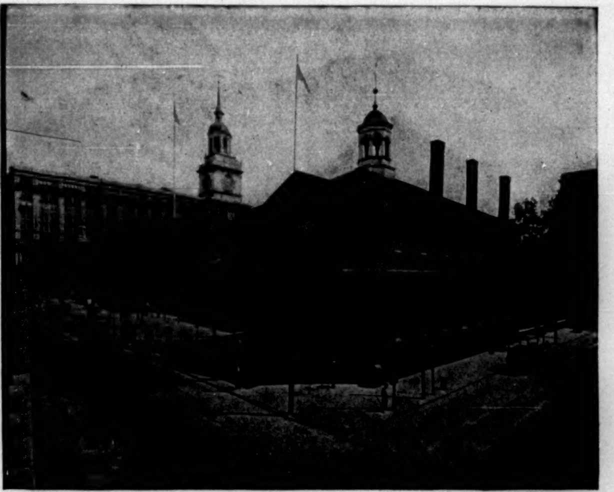
XIV. A curious Machine acting by means of the Electric Fire, and playing Variety of Tunes on eight muſical Bells.

XV. A Battery of eleven Guns diſcharged by a Spark, after it has paſſed through ten Foot of Water.

As the Knowledge of Nature tends to enlarge the human Mind, and give us more noble, more grand, and exalted Ideas of the AUTHOR *of Nature, and if well purſu'd, ſeldom fails producing ſomething* uſeful *to Man, 'tis hoped theſe Lectures may be tho't worthy of Regard & Encouragement.*

☞ *Tickets to be had at the Houſe of the Widow* Allen, *in* Thames *Street, next Door to Mr.* John Tweedy's. *Price* Thirty Shillings *each Lecture. The Lectures to begin each Day preciſely at* Three *o'Clock in the Afternoon*

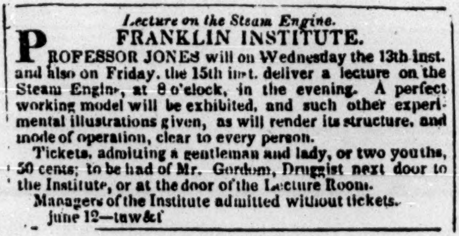
Handbill of the Kinnersley Traveling Electrical Show. The original is the property of Dr. A. S. W. Rosenbach.



The birth of The Franklin Institute was literally centered about Independence Hall. The preliminary meetings were held in the hall of the American Philosophical Society, on the far side of the State House, while the actual organization was held in the County Court House, in the foreground.

people who were employed in the daytime led to the inauguration of evening schools. In addition to the sciences, which were the fundamental purpose of the beginning of the Institute's classes, demand caused the formation of groups studying Geography, History, Latin, Greek, French, Spanish and German. By 1827 more than 300 pupils were enrolled.

It was upon this pattern that Central High School was later established by the city as part of the public school system. As soon as the



Lecture on the Steam Engine.

FRANKLIN INSTITUTE.

PROFESSOR JONES will on Wednesday the 13th inst. and also on Friday, the 15th inst. deliver a lecture on the Steam Engine, at 8 o'clock, in the evening. A perfect working model will be exhibited, and such other experimental illustrations given, as will render its structure, and mode of operation, clear to every person.

Tickets, admitting a gentleman and lady, or two youths, 50 cents; to be had of Mr. Gordon, Druggist next door to the Institute, or at the door of the Lecture Room.

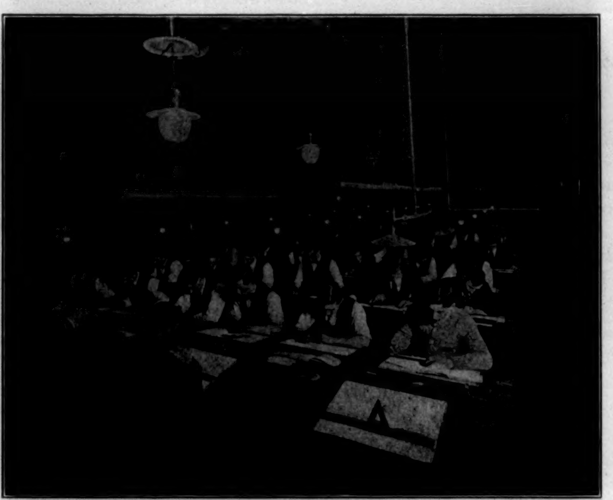
Managers of the Institute admitted without tickets.

June 12—tuw&t

Early Lecture Announcement.

public schools accepted responsibility for teaching a subject, it was dropped from the Institute roster, so that more attention could be paid to scientific classes. The School of Mechanical Drawing was continued for 99 years before being dropped, just prior to the Institute's Centenary.

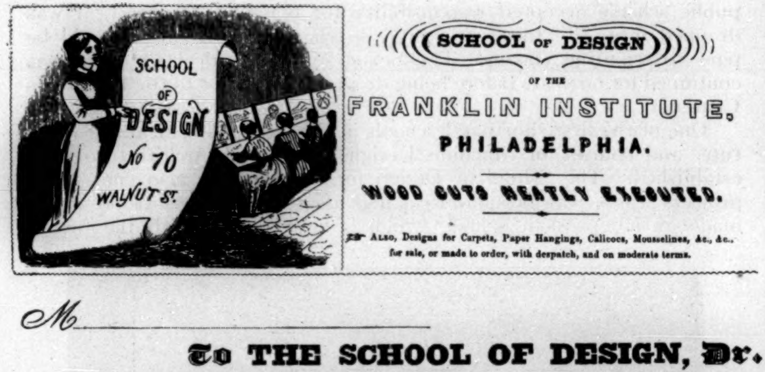
One of the first shorthand schools in the city was held at the Institute, and courses in Machine Design and Naval Architecture were established. The School of Design for Women was also one of the projects which was brought to a high degree of success before being made an independent school, which is now merged with the Moore Institute of Art, Science and Industry. The Franklin Institute was active in the establishment of the School of Industrial Art, whose classes were, for some time, held in the Institute building.



This photograph of the class in mechanical drawing was taken about 1907.

The exhibitions which the Institute inaugurated as soon as it was organized became outstanding events in the presentation of scientific progress to a public which was constantly becoming more and more aware of the significance of science.

Through the century which followed the Institute's organization, teachers came to be more and more aware of the value of what it offered both to them and to their students. Teachers from all parts of the city frequented the library and many are today's industrialists who


SCHOOL
OF
DESIGN
No 70
WALNUT ST.

SCHOOL OF DESIGN
OF THE
FRANKLIN INSTITUTE,
PHILADELPHIA.

WOOD CUTS NEATLY EXECUTED.

☞ ALSO, Designs for Carpets, Paper Hangings, Calicoes, Mousselines, &c., &c., for sale, or made to order, with despatch, and on moderate terms.

M________________________

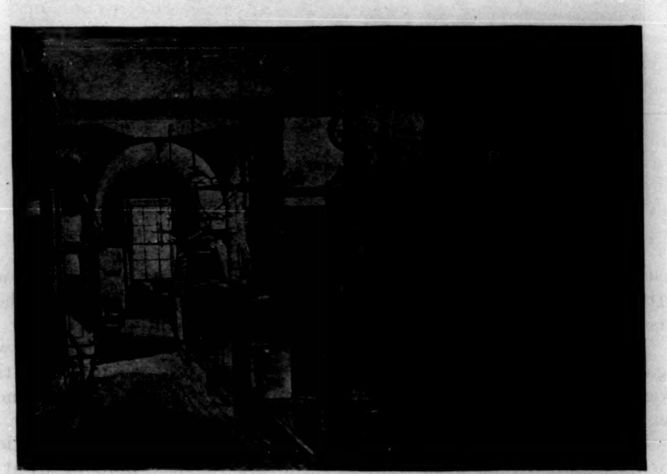
To THE SCHOOL OF DESIGN, Dr.

Billhead of the Institute's School of design for women.

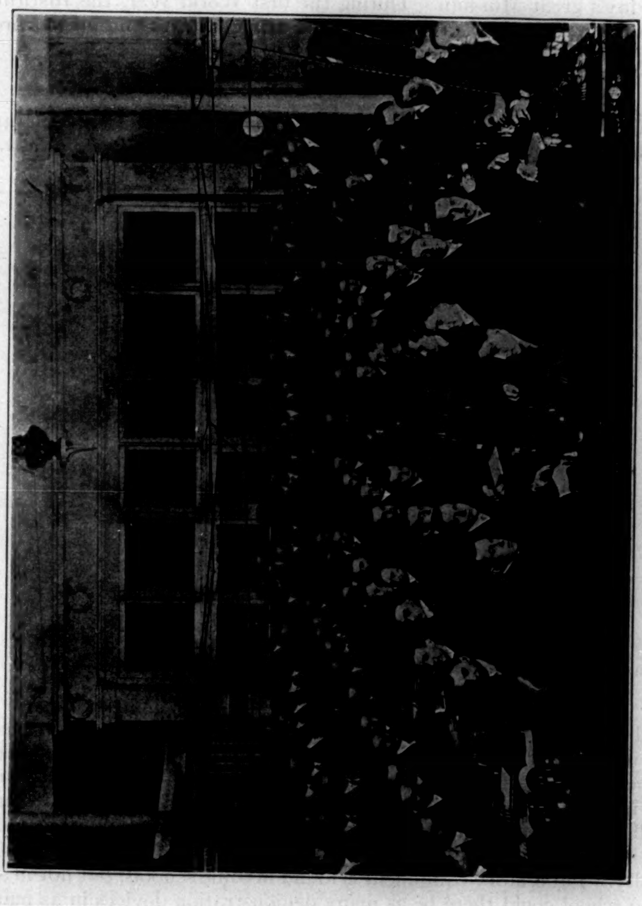
point out that, as children, they used to make the Institute their second home.

And that was before the Institute had really developed for such an audience.

From the very beginning, the visual education technique was em-



Some of the early exhibits collected by the Institute. From a painting by Colin C. Cooper, Jr. Notice Benjamin Franklin's original electrostatic machine.



The class in radio held for the government during 1917 and 1918.

ployed. Models were brought to the Institute by inventors to explain their offerings, and these were used in class work. A collection of demonstration equipment grew gradually until the nucleus was formed of today's great Museum. During the first World War, the Institute conducted a School of Navigation for the United States Shipping Board, and a free Radio School for men of the selective draft.

THE CONCEPT OF A VISUAL EDUCATION EMPORIUM.

When the decision was finally reached to build a great new structure which should serve as a national memorial to Benjamin Franklin, it was concluded that no finer project could be found than the establishment of a museum of science and industry in which visual aids to education in the technical sciences might be brought together and exhibited in a well-integrated plan. There would be a huge building which would fulfill the educator's dream of helping to dramatize the subjects which, in a less fully equipped classroom, might well be difficult to present vividly. Laboratory equipment is found in some schools, but not in all. In no school could there be as many demonstration devices in as many fields as would be found in the Museum. There would be no "hands off" signs. The exhibits would move,—could be worked by the visitors.

Swarms of students like these are not so frequent since war came, but schools can and do come to the Museum even if they have no buses. Photo by Gladys Muller.

Such a Museum was not new. There were several in Europe and these were visited and studied. Their programs were analysed, and a unique one set up for the Institute's great new venture.

On November 6, 1933 the Fels Planetarium opened its doors to the public. On January 1, 1934, the Museum began to welcome a stream of visitors which still continues.

ENTER THE TEACHERS.

Immediately teachers of schools in the Philadelphia area began to come to the Institute, to demonstrate through its exhibits things they had been discussing in class. Teachers by the hundreds, pupils by the thousands, have been coming to the Institute constantly ever since the very first day they were admitted. Many of these teachers have been using the Institute's facilities time and time again,—and the Museum officials may not hear about it for years. Some schools have made it a practice to schedule regular visits as a part of their routine program. Many men and women, without so much as indicating their intentions, have spent hours in the Museum in advance of their trips with students, so that they could do a thorough job of preparation. Some of them made up their own outlines for special purposes.

The model Fourdrinier paper-making machine, the only scale model in existence, is one of the favorite objectives for school visits. Photo by Gladys Muller.

It was not long before schools came to realize that an unplanned, uncoordinated trip which attempted to cover the entire building in one whirlwind tour was likely to be productive of tired feet and spinning heads. Yet Institute officials have all too often heard people express the opinion that another trip to the Museum or Planetarium was unnecessary,—the visitor had already been there. From the beginning it was realized that one of the major aims was to publicize the Museum to educators as a teaching aid in itself . . . a teaching aid of unparalleled quality and quantity. Underlying every exhibit in every department was the fundamental purpose of helping in the explanation of the behavior or application of science. The entire Institute had become synthesized into a gigantic educational project, which would be of the greatest value to those persons who used it most intelligently. All contacts with schools were principally the function of Miss Elizabeth Connelly, Miss Mary Barlow and Henry S. Harris of the Public Relations Department.

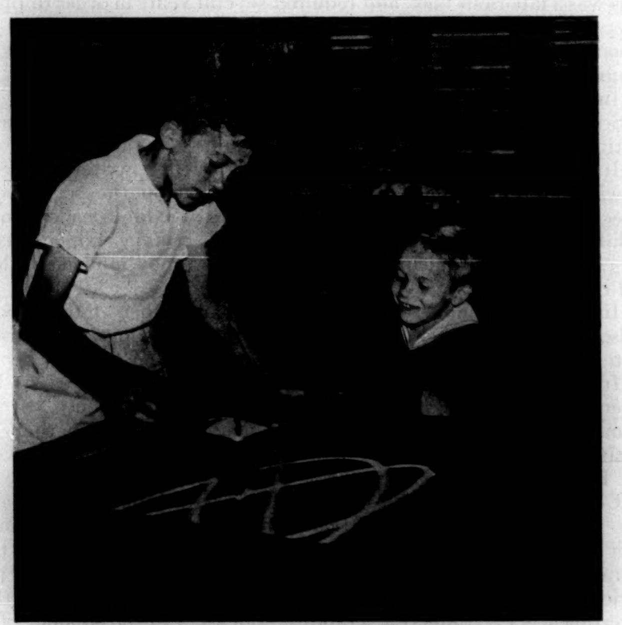
SCHOOL ADMISSIONS.

In accordance with the practice adopted by the Institute upon the opening of the present building eleven years ago, all students of Philadelphia public and parochial schools are admitted to both the Museum and Planetarium without charge. When they come in groups, under the supervision of a teacher, it is necessary only for the teacher to have made a reservation or to identify himself. No tickets are required. However, it is very desirable that children learn to get the Institute habit, and to encourage this, an unlimited number of tickets entitling pupils to individual free admissions to the Museum or Planetarium is distributed each year to the public and parochial schools of Philadelphia. These are available to principals and teachers upon request, either to the Department of Visual Education or to the office of the Diocesan Superintendent of Schools. All other schools in the Philadelphia area are given special educational discounts. This fall one hundred seventy-five thousand student identification cards were sent out to nearby counties and to private schools, to be issued to students. All teachers of all schools are entitled to identification cards which grant them unlimited use of the Museum and Planetarium without charge.

THE BEGINNING OF SCHOOL-MUSEUM COORDINATION.

It was not long before teachers learned to sense the tremendous possibilities of this new museum, which touched their school work in more separate fields than any other museum that they had ever known. They began to ask questions of the guides, and of the staff members. They realized that some coordinated preparation would be valuable. Other museums, they knew, had long been studying the most effective use of student visits. Not at all unnaturally, the first enthusiastic tours of the Institute in its new home were gasp-producing flittings from one highlight to another. Yet anyone who has been active in either school or museum work is well aware that such visits are little more valuable than any other afternoon off from the routine of the classroom.

During this period of mutual getting-acquainted, Richard W. Lloyd, chairman of the Museum Committee of the Board of Managers, began to spend a substantial amount of time in the Museum, talking with staff members and answering queries from educators. In his analysis of the needs of the Institute a closer teacher-Museum relationship became of even greater importance than it had ever been before. He conferred with science teachers and other educators in order to determine what might be offered which would be of greatest value to the schools of the Philadelphia area. It soon became clear that the Institute had both an obligation and an opportunity to render a more complete service to the schools of the Philadelphia area. For several years George C. Galphin, of Drexel Institute, was of material assistance in developing the school program.



The composition of simple periodic motion develops appeal through the medium of a swinging sand pendulum. Photo by Gladys Muller.

The Board of Managers created the Department of Museum Education, and named Mr. Lloyd the Director. He studied the way in which other older museums were tackling the same sort of problem and then began a constructive program of preparing teaching aids which could be made available to teachers before they brought their classes on visits. Outlines were prepared covering each department of the Museum, stressing the desirability of a limited scope for each study visit. This was a laborious task, and required several years in order to produce a representative amount of information covering the complete field. Schoolmen were delighted with such facilities, and a number of them volunteered their cooperation in organizing the material.

In this work the services of Miss Gertrude M. Elcock, former Head of Springside Middle School, were very valuable in interpreting the Institute's exhibits to both teacher and pupil.

In the summer of 1942 Dr. Arthur D. Graeff, a writer and teacher of wide experience, helped the Institute develop the social science aspect of its exhibits, particularly by a series of exhibit leaflets entitled "Philadelphia at Work." These featured certain exhibits closely associated with Philadelphia and showed how they influenced the life and times of our city.

In the same summer William S. Berry, a teacher at the Woodrow Wilson Junior High School, helped work out plans for greater use and better coordination of exhibits in the Chemistry and Electricity Sections.

In July, 1940, Dr. J. Hubley Schall joined the staff as Assistant Director of Museum Education. His previous experience with museums in New York and his work with young people strengthened the Institute's educational activities. In September, 1941 he succeeded Mr. Lloyd as Director.

Contacts with the schools were greatly increased and more teaching aids were produced, with particular reference to closer coordination with various phases of school curricula. Teachers continued to cooperate actively in various phases of the Institute's cooperative plans. Various sections of the Museum were coordinated to fit in with the government's Pre-Induction Training Courses. In the summer of 1943 Dr. Schall joined the American Red Cross as a field director in the overseas military service. His three years of planning and development work with educators in the Philadelphia area are still producing results.

During the early part of the war it was taken for granted that there would be a falling off in the number of school visits to the Institute, because of curtailed transportation facilities. This drop materialized, but it was not so marked as had been expected, while during the course of the past year there has been a noticeable increase in the attendance of both city and suburban school groups. Interestingly enough, the percentage of increase has been greater in the out-of-town schools than in the Philadelphia groups.

It has been noted that the majority of school groups are now making advance reservations for their visits either to the Museum or Planetarium, and they are coming with specific objectives for their study visits, instead of just "going to the Franklin Institute"—the end for which Institute officials have been aiming for years.

MUSEUM RESEARCH.

Major Thomas Coulson, Director of Museum Research, has been making intensive studies of the entire Museum, section by section, in order to collect a vast reservoir of background information which may be used both for educational and for general research or publicity purposes. Not only are the technical data concerning each department being brought together in one place, but also historical and collateral social references which are already, even though not yet complete, of tremendous value in connection with all of the many fields the Museum covers. The information which has been gathered together on both the Prime Movers and Marine Transportation Sections is a veritable treasure trove, and a similar handling of the other facets of the Museum will make available material which has always been desired, but which has, until now, been all but unattainable.

SPECIAL PLANETARIUM SHOWS.

For a number of years special planetarium demonstrations for school children were given at *unscheduled* times. This was possible because schools were able to send classes in to the Institute in buses, and other schools were invited to join in the special show. Selected lectures were given, usually by Dr. William L. Fisher, and these were extremely popular. The curtailment of school buses made it necessary to abandon these shows, but they will probably be resumed as soon as pupils are able to come to the Institute without taking an inordinate amount of time for the trip.

One of the interesting collateral uses of the Planetarium has been its employment by a group of classical clubs for special lectures devoted to the mythology of the skies. Such a use of an astronomical instrument to increase the appreciation of Latin and Greek is audio-visual education in its purest possible sense.

SCHOOL ASSISTANT.

For some time it has been hoped that the Philadelphia Board of Education would assign one of its teachers to The Franklin Institute to help in working with the schools. It had been thought that this project might have to wait for the post-war period, but during the past summer Dr. John C. Garman, Director of the Department of Visual Education of the Board of Education, designated Miss Mabel G.

Rhoads to help the Institute in its program of cooperation with the schools.

Miss Rhoads is a trained teacher, who is also well versed in Museum technique, having spent several years doing the same sort of correlation at the Commercial Museum. Fundamentally her work will be that of liaison between the schools and the Museum. She is already visiting schools to hold conferences with teachers and principals, urging more and better use of the Museum and Planetarium and helping teachers develop plans for study visits. She spends part of her time in the Museum, actually escorting school groups through the building in accordance with a prearranged study plan, and gives lectures on any of a number of different topics which may be requested. At the present time she is stressing a survey of Philadelphia industries, to fit in with the Board of Education's current "We Philadelphians" campaign. She will also assist in the preparation of whatever written material may be necessary in connection with this expanded program. Requests for her cooperation in planning study visits should be addressed to the Institute.

When the stars come on in the Planetarium, school children,—and grown-ups, too,—react in the same way. Photo by Gladys Muller.

CURRICULUM COORDINATION.

The work of Miss Rhoads is the beginning of what may very well develop into a five- or ten-year plan. The broadness of the scope of the Institute is too well known to require repetition for emphasis. Dr. Charles Russell, Chairman of the Department of Education of the American Museum of Natural History, once wrote:

"Since the field of the Museum (A.M.N.H.) extends laterally to infinity and the clientele of the Museum vertically through the range of the human mind, all programs of the Department must be selective."

The Franklin Institute confesses that its field is less broad . . . the physical sciences may be designated as having boundaries,—infinity minus, perhaps. And the program of our department in working with the local schools is likewise somewhat less extensive. This horizontal-vertical program of Museum-School correlation has been the subject of several conferences with Dr. C. Leslie Cushman, head of the Board of Education's Department of Curriculum; Dr. John Mason, his Editorial Assistant; and Dr. Gladys V. Benner, chairman of a committee for the revision of the science curriculum. In these talks it has been concluded that the tie-up between the Institute and schools can best be systematized if the horizontal coordinates are the individual fields of science which the Museum covers, while the vertical coordinates are the areas of study of modern education. Thus there will be, if the job is ever completed in form to be usable for every phase of education, several hundred separate stories, and each of these might be interpreted from several educational levels. While Dr. Benner is preparing the basic outline of this plan, it is probable that actual work will be set aside until more assistance is available.

It is assumed that by the time such a thorough plan is made more operative, there will also be greater ease of transportation for school groups, and they will come to the Museum more frequently and in larger numbers. Present activity is largely preparatory to this end, although it also serves a substantial end in itself.

TEACHER TRAINING.

The place of the Institute as the city's center for astronomical information is well evidenced by the number of requests which have been received from time to time for correct explanations of heavenly phenomena or for data concerning the stars. Many teachers, particularly after they have brought students to the Planetarium, have expressed the wish that they could inject some astronomy into their class work in geography, general science, history or literature, but they have hesitated on two scores: few of them have ever studied astronomy, in the first place, and, in the second place, the demonstration equipment necessary was both too elaborate and too expensive. These repeated comments caused Dr. Roy K. Marshall, Assistant Director of the Fels Planetarium, to suggest a so-called "Astronomy Clinic" whose announced intent was to teach teachers how to teach astronomy with the aid of apparatus which they could easily make from odds and ends to be found in a desk drawer or in the five and ten cent store.

Last fall the Department of Museum Education sent out a query to see if there was any interest in such a series. It was very gratifying when more than two hundred answers were received. A second letter was sent out, asking for further suggestions about the content of the proposed clinic and urging advance registration. More than three hundred registrations were received. By the time the series began, in January of this year, it was decided to conduct four rather than three sessions. They were held on consecutive Wednesday afternoons. The average attendance was about three hundred fifty. Dr. Cushman and Paul Long, assistant to Dr. Garman, represented the Board of Education; A. W. Castle, Chief of Extension Education of the Pennsylvania State Bureau of Public Instruction, also observed the clinic in session. Educators, recognizing that this was an admittedly experimental effort, were enthusiastic in their praise. It was the first time, they pointed out, that any such opportunity for teacher training had been offered.

To help in making more usable the material presented in the Astronomy Clinic, Dr. Marshall wrote a "Teachers' Manual" which was sold for its physical cost. This handbook gives outlines of the material which may be presented in a number of different lessons even though a teacher has had no training in astronomy, and there are instructions for the manufacture of simple and inexpensive demonstration equipment.

From all angles the response to the Astronomy Clinic was overwhelming. There have been literally hundreds of requests for a repetition of it, and also for similar clinics in other subjects. Particularly urgent have been the suggestions that a clinic be devoted to general science for elementary schools. It appears that, while junior and senior high school levels have demonstration equipment available, and the teachers in these grades usually have had some training in the field, an introductory clinic might help the lower grade school teacher to introduce the younger children to science in a more adequate manner than is now possible. Another request has been for a clinic in meteorology and weather forecasting. These requests have been carefully studied by the Museum staff, and it has been regretfully decided that the present shortage of personnel makes it impractical to develop the program further at the present time. With members of the technical staff engaged in other activities, proper attention cannot be given to the preparation and presentation of such programs. However this is definitely a high priority post-war program.

One project in teacher training which is being undertaken at the present time is a series of conference-tours for groups of teachers to outline proper museum procedure and use of museum facilities and to indicate some of the functions and services which do not normally meet the eye.

SCHOOLS OF EDUCATION.

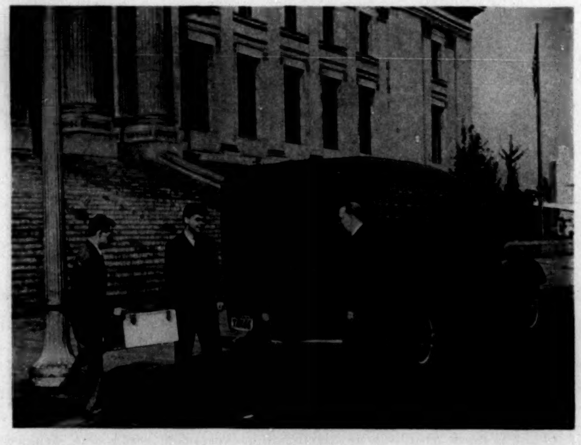
The number of visits by young men and women who are actually studying to be teachers is extremely gratifying. Teachers Colleges, Normal Schools and Universities send students in their educational courses in to study the Museum and what it has to offer. This not only gives them an object lesson in the technique of utilizing community assets, but makes them sufficiently familiar with the Museum so that, when they start to teach, they can urge their own pupils to get to know the Museum.

Not infrequently such groups come from scores or even hundreds of miles for this purpose. A recent visit from the head of the Educational Museum of the public schools of a midwestern city resulted in enthusiastic,—and wishful,—praise. "Do teachers in this state know how lucky they are?" she asked.

The flow of air is made visible in an aerodynamic experiment which was included in the traveling air show. Photo by Gladys Muller.

TRAVELING SHOWS.

Two spiritual descendents of Benjamin Franklin's own traveling shows were prepared by the Museum staff a few years ago and circulated throughout a large portion of the United States. This new educational feature sprang from a series of individual demonstrations which had been given in the Museum by Dr. Nicol H. Smith, head of the Chemistry Section. One show was devoted to dyes, another to perfumes, another to liquid air. The essential element in all the experiments was the dramatic and colorful presentation of a technical story. So much interest was aroused by these programs when presented in the Museum that they were edited and brought together to form one complete show. Ralph H. McClarren, head of the Aviation Section, did the same sort of job in his field. There were demonstrations of flight in nature, of aerodynamic principles, of flying models, and explanations of modern aircraft. A staff of demonstrators was trained to take these two shows, in their specially equipped trucks, to schools and other interested organizations. Henry S. Harris was charged with the promotion and routing of these two shows. They were seen by half a million people, from Massachusetts to Virginia, and from Michigan to Louisiana.



The trucks for the traveling shows were arranged so that the demonstration equipment was easily portable. Photo by Gladys Muller.

Wherever the Museum thus carried its message to the public, there was a vast amount of enthusiasm. However the coming of war forced the suspension of this activity. The young lecturers who had been in charge of the traveling shows were eligible for military service, and the problems of transportation became acute.

Now, several years afterward, requests are being received weekly from schools all over the country, asking how soon the old shows are going to be revived . . . and what new traveling shows will be available. The development of these is another high-priority project for the post-war period. As soon as men are available to bring the shows up to date, to recondition the old equipment, to construct new apparatus and to do the demonstrating, and as soon as transportation facilities are improved, it is hoped that the Aviation and Chemistry shows will again go on the road. It is believed that there are already enough requests for them to take care of the greater portion of a year's itinerary without any necessity to cultivate new fields.

Work on a traveling Electricity show to be called "Electro-Magic" had already been begun by William P. West, the Institute's electrical engineer. Work on this series stopped when it became evident that the other two shows could not be continued, but will probably be revived. Other possibilities are Astronomy and Meteorology.

It is very definitely indicated that the resumption of this educational service by the Institute will be welcomed eagerly. It is a project which, when carried to its fullest development, will carry the educational work of the Institute to the people of the country as no other single function ever will.

A complete set-up of the shows could be arranged quickly in any school auditorium or meeting hall. Photo by Gladys Muller.

In the beginning, the aviation show was partly underwritten by a grant from the Carnegie Foundation and the chemistry show by funds supplied by a friend of the Institute. When revived they will probably necessitate lecturer-demonstrators, technicians and clerical assistants, as well as funds not now available.

LOAN EXHIBITS.

As is true with all Museums, there occasionally come to the Museum items which have interest and educational value, but, for a variety of reasons have been relegated to storage. It is well recognized that these exhibits are utterly valueless as long as they are not in use. The modern interest in and demand for visual aids in classrooms has pointed the way for an early transformation of this dormant material into active aids for local schools. The readjustment of some of the Museum departments because of current conditions made it possible to get an active start in this field, and this has been done with the grateful cooperation of officials of public, parochial and private schools of the city. Some of the exhibits which go to the schools on loan have real constructive value, such as, for example, a small electric saw. Several locomotives and freight cars, three or four feet long, are now delightful play-toys in three kindergartens. A central city school displays an unusable but interesting antique printing press, beside a serviceable etching press. The Catholic high schools are sharing the use of demonstration equipment in physics.

This is still a very young activity, and the *modus operandi* has just been developed. The Department of Museum Education will act as agent between the schools and the Museum and will try to match the requests from schools against the list of available exhibits. The borrowing school is, of course, responsible for transportation, insurance and any other incidental costs, and guarantees suitable care.

A new activity, recently inaugurated, is the loan of a small portable telescope to school groups for an evening of star-gazing. Science teachers, astronomy clubs, parent-teacher associations or other school groups may arrange to pick the telescope up and transport it to the school grounds at some time when there will be interesting things to look at. The astronomy department of the Institute then assigns someone to go to the school, to operate the instrument, and to explain the objects being viewed.

CIRCULATING EXHIBITS.

A field in which many other museums are far ahead of The Franklin Institute, and which must be studied and developed in the not too far distant future, is that of small simple exhibits (often called suitcase exhibits) which can be withdrawn for a short period in the same manner as a book is withdrawn from a library. The Department of Museum Education at the moment has only a handful of items which would be suitable for this purpose,—and has neither space available to display them, nor funds and personnel to create more. It is not worth-while to inaugurate a plan for so few items. Suitcase exhibits have been found by museums all over the country to be among the greatest educational aids which can be offered. In Philadelphia the Academy of Natural Sciences, the Commercial Museum and the University Museum have rendered outstanding service along these lines. In New York, Cleveland, St. Louis, Chicago and in many smaller communities this field of museum service has been built up to magnificent proportions. Plans for similar activity on the part of The Franklin Institute are being accumulated gradually. Some exhibits are already designed and specifications drawn up, others are simply listed as being desirable. Obviously this project will rest *in statu quo* until such time as much more space, personnel and funds are available.

SLIDES AND MOVIES.

Another field of visual education which has been given scant attention in the Institute up to the present time is the building up of a library of lantern slides and motion pictures which may be borrowed by schools for use in the classroom. This is a potent means of actually helping teachers to tell a specific story which ties in with the class work, and also of bringing the Institute's message to the schools at a minimum of cost and effort.

This situation is now being rectified in a manner which assures a steady, albeit slow, accumulation of slides. They are being ordered, primarily to help Miss Rhoads tell her story about the Institute when she visits schools or to highlight her talks when school groups come to the Museum. The first series prepared is a general tour of the Institute, with photographs of the outstanding exhibits. Further collections will be made in connection with individual sections or with specific subjects.

Some day a motion picture showing the action exhibits of the Institute will carry the name and fame of the Museum all over the country. There have been scores of requests for such a film, but this is definitely a project for the future,—and, while it will be useful, there are other things which are much more important.

COOPERATIVE COURSES.

One of the problems which has been facing all secondary schools in recent years has been that of preparing their senior boys for military service. One of the Institute's most enthusiastic supporters is Greville Haslam, headmaster of Episcopal Academy. He points out to his students how extraordinarily fortunate they are in having a place like the Museum and Planetarium to make their school work in science more vivid and meaningful. In the fall of 1943 Mr. Haslam suggested that the Institute might render a valuable cooperative service to such schools as were trying to equip their graduates for Officers' Candidate School or for entrance into the air services. He suggested that his science master, Robert W. Neathery, work with the Institute in outlining a series of sessions which might be given as a special course for interested boys. It was decided that ten lectures be given, covering such fundamental principles of astronomy and meteorology as might be helpful in military flying. In these subjects, it was felt, the Institute could render more marked service than in others, which might be taught effectively in the classroom. Since it was desirable to complete the series of lectures before the spring sports schedules would interfere, there was time to do no more than to notify the various school authorities that the series was proposed and would begin the following week. There were more than sixty students, from Episcopal Academy, Penn Charter School, Friends' Central and Friends' Select Schools. The most important result was not only the gratification of the boys and their science teachers, but the valuable information and experience gained by the Institute in offering similar courses in the future. None are immediately in prospect, but several collateral courses have been suggested and will be considered later.

RADIO.

A new radio program was launched early this fall directed toward the elementary schools, adopting the theme "Science is Fun." The project was suggested by Miss Gertrude Golden, one of the District Superintendents of the Philadelphia Board of Education, and chairman of the Board's Public Relations committee. A steering committee was appointed to represent the public, private and parochial schools. Ruth Weir Miller, of the Radio Committee, was given charge of the project. The program, which is being broadcast over Station WFIL every Monday at 2:15, will dramatize interesting events of science, with special reference to current anniversaries, and will also highlight offerings in the Museum and Planetarium. Egbert, the famous mechanical man, is being brought to life for each broadcast and is acting as guide for visiting children who actually appear in each broadcast. The first broadcast in the series brought almost a thousand letters from students and teachers.

To make the broadcasts more useful in the classroom, a Teachers' Manual, containing synopses, suggested activities, vocabularies and booklist, was prepared and distributed by WFIL to every teacher of grades three to six in Philadelphia, and to any in the surrounding area who requested them. An evaluation committee was appointed to visit schools during each broadcast, to watch the reactions of pupils, and to make criticisms or suggestions.

Another program, directed to the high school level, is being presented over Station WIP on Tuesdays at 1:45 P.M. This weekly show, entitled "Great Moments in Science," is being prepared and presented by Dr. Roy K. Marshall, and employs an entirely different technique from any other program the Institute has ever presented.

The possibilities of television for Museum Education presentation are being kept clearly in mind. Already there has been some experimentation with this medium of the future, and the resumption of television broadcasting on a regular schedule will find the Institute ready to make educational offerings.

TEXTBOOK COORDINATION.

During the past year a collection has been made of many of the textbooks which are approved for use in the teaching of science and the social sciences. It is planned to correlate the Museum exhibits with these books, so that teachers will know, when instructing their classes, in just what fields the Institute will be able to help them,—and how. In the summer workshop of the Board of Education, several teachers expressed interest in this program and have indicated their desire to volunteer their help if the project can be put into operation.

APPRENTICE TEACHERS.

An experiment was tried in the Astronomy Department recently when a Wellesley astronomy major spent the summer as an apprentice, acting as guide in the Hall of Astronomy and the Observatory, and also helping the staff with much of their routine work. This gave her an opportunity to get some experience which would have been virtually unobtainable under any other circumstance, and the astronomers were delighted to have a capable aide during the period. Similar opportunities may later be available for other teachers who are interested in learning more about the audio-visual education field as it exists in the Institute.

During the past summer Henry C. Evans, science teacher at William Penn Charter School, spent his vacation helping the Department of Museum Education in consolidating some of its present plans. His activities were a combination of functions which gave him an opportunity for study and research while rendering very welcome service to the Institute.

EXHIBIT COOPERATION.

A field of Museum-School cooperation hitherto completely uncultivated by us was explored a couple of years ago, when the Hall of Weather was first opened to the public. An exhibit was needed to tell the story of air pressure. William S. Berry suggested that it was the sort of project which the boys in his school might enjoy tackling. The Institute furnished the necessary materials and the idea, and the boys did the work as a shop project. They not only enjoyed doing the work, but were proud to know that their school had had a part in the new department. In the same way, murals were designed and executed by both the Springside School and the Agnes Irwin School.

Such a program as this may be developed further at some later time, particularly to supply gaps in some story which the schools themselves may want to tell.

FRANKLIN JUNIORS.

Several years ago a number of student members of the Institute organized a group and began work upon a project which, had it not been for the war, would by this time have resulted in at least one major exhibit, a scale model of the WCAU radio transmitting station. For the duration the activities of the Franklin Juniors have been limited by lack of space and inability to assign specific projects. These boys, however, are looking forward to a resumption of their active work for the Institute at some later time.

SCIENCE CLUBS.

In many of the schools in the Philadelphia area there are groups of students who may someday be enlisted in a program of activity which will benefit them, and, at the same time, may help the Institute itself to render a fuller service. Any number of adult hobby groups might be brought into closer contact with the Museum's educational work. The Philadelphia Ship Model Society has already been very cooperative, and there are similar organizations whose help may be enlisted.

REHABILITATION.

The possibility of making the Museum a center of vocational guidance for returning service men is being carefully studied. Men active in the field of vocational guidance have been enthusiastic about the superb facilities of the Museum in helping a counselor in exploratory, checking or tryout work. Conferences have already been held with officials of the State Bureau of Public Instruction in this matter, with officials of the Veterans' Administration, the Board of Education, and other agencies interested in this important activity.

SUMMARY.

The work of the Department of Museum Education is broad, indeed. It could be much broader. It is well recognized that we are but skimming over the surface of the permanent possibilities. It is only too clear that there are few departments of museum-school correlation in which some other museum, somewhere, has not done a much better job. These museums are models after which we may try to pattern our program. However there is no other museum whose fields of service are so sure to be felt in the normal impact of daily life. The schools know this,—and so do we.

It is our belief that we are fulfilling a program that might well have been laid down either by Franklin himself, or by the men who founded The Franklin Institute. It is an endless program, because science itself is endless. It is an endless program because there will always be new teachers . . . there will always be new pupils . . . there will always be a new story to tell them . . . there will always be new ways to tell the story.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

WET-STRENGTH PAPER FOR MODERN WAR MAPS.

An account of the development of the paper for our improved war maps, and its manufacture in quantities necessary to meet unprecedented requirements, is a story of accomplishment through cooperative effort. The new paper, which is responsible for the remarkable performance of the maps under all conditions of current combat service, was developed by the Army Map Service in cooperation with the Bureau and with the wholehearted assistance of certain paper manufacturers.

The new paper has greater strength than any previously used for maps, and retains this strength after being soaked with water or oil, or after being trampled in the mud, and subsequently washed with soap and water, or dipped in gasoline. Even when soaking wet, the paper has satisfactory writing and erasing characteristics. In addition, it has good printing properties, and meets all the usual requirements of map paper.

The Bureau has had an important role in extending the commercial manufacture of this paper to widely distributed mills and in utilizing different types of raw materials so as to increase production and to meet the rapidly expanding needs of the armed forces. Two difficult problems were involved: (1) It was necessary to bring into production an entirely new type of paper in mills not familiar with its manufacture, and (2) the supply of the special pulp used in this paper as originally developed became extremely short and it was necessary to employ pulps previously untried for the purpose.

These problems were solved on a production basis by sending an expert from the Bureau to the different mills that had been selected by the Army to receive educational orders. Charles G. Weber, who had been closely identified with all phases of the development and testing work, served as a technical consultant to 11 different mills and worked with the staff of each until a paper meeting all the requirements of the specification was obtained.

The map paper is now being produced in mills distributed from coast to coast and from the Gulf of Mexico to the Canadian border. Moreover, pulps from eastern spruce, southern pine, western hemlock, and the jack pine of the Great Lakes region are used with equal success. The current requirement is well over 10,000,000 pounds per month, and this huge tonnage is being supplied without departure from the original high standard of quality.

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* Communicated by the Director.

PLASTIC BINOCULARS.

In April 1942 the joint optics committee of the Army-Navy Munitions Board met to consider possible replacement materials for the aluminum used in binocular bodies. The Material Officer of the Naval Observatory recommended that binoculars be fabricated from a plastic material. A development program was initiated at the Naval Observatory in cooperation with the Bureau to obtain a suitable plastic for this purpose and to produce and evaluate the plastic binoculars.

Bodies for the standard 7 × 50 Navy binocular were molded from a selected group of plastics, and assembled into complete binoculars. These were subjected to accelerated service tests, involving exposure to extremes of temperature and relative humidity, and measurements were made of optical and dimensional changes. The binoculars were also subjected to shock and impact tests. The results of these tests indicated that a thermosetting phenolic molding compound, containing a long-fiber asbestos filler, had the necessary strength and dimensional stability for this application.

A special 6 × 42 binocular design was developed by the Naval Observatory to utilize fully the advantages of the plastic material. This binocular has a field and light-gathering power similar to that of the 7 × 50 type; weight comparable to that of the 6 × 30 type; fixed focus and fixed interpupillary distance, eliminating the necessity for axial and eyepiece adjustments; waterproofness at a depth of 100 feet of water; resistance to fungi and corrosion; and an embossed gripping surface imparted during the molding operation, thereby eliminating the necessity for a separate covering material. It is a compact binocular, containing a minimum number of intricate parts, and readily lending itself to mass production. The metal inserts which retain the optical elements are die-cast of a light-weight aluminum-silicon alloy which was selected because its coefficient of thermal expansion closely approximates that of the phenolic plastic and hence makes negligible the strains arising from differential expansion of the plastic and metal.

Evaluation tests performed on the 6 × 42 plastic binocular indicate that it satisfactorily fulfills all the requirements for a general-purpose service binocular. Its rugged construction and fixed adjustment features make the plastic binocular exceptionally well suited to specialized service such as night, tropical, amphibious, infiltration, small vessel, and submarine use.

ANTI-SCATTER TREATMENTS FOR GLASS.

The results of an investigation of the effectiveness of various anti-scatter treatments for glass, which was sponsored by the Office of Civilian Defense, are reported in Miscellaneous Publication M175, which was released last month. These treatments are designed to reduce the hazard of flying glass from bomb explosions—a hazard which has been responsible for a large proportion of the air raid casualties in England.

A vacuum-concussion apparatus was used for evaluating the suitability of the various anti-scattering treatments. The glass specimen is clamped as a cover over a tank connected to a vacuum reservoir. The opening of a quick release valve causes a sudden reduction of pressure inside the tank and the glass is fractured by the air pressure on the outside of the pane. The relative effectiveness of the treatments was judged by the types of failure and the amounts of flying glass.

The treatments which gave promising results in the initial vacuum test were submitted to accelerated aging tests to ascertain how well they might be expected to retain their desirable properties in service. One test simulated the effect of moisture condensing on windows in cold weather. Another test simulated the drying effects of warm rooms in winter and the heat of the sun in summer.

Lacquers, tapes, and adhesive-fabric materials were found which would maintain satisfactory breaking characteristics after submission to the aging test. An adequate film thickness, at least 0.020 inch, must be applied in the case of the lacquer, and the tape must completely cover the pane in overlapping strips in order to prevent glass from scattering.

It should be recognized that no anti-scatter treatment can be considered as giving complete protection from the hazards of flying glass. Laboratory tests and experience in Great Britain have shown that certain treatments will give some measure of protection over part of the area affected by a bomb explosion. However, in or near an area where bombs are likely to fall, individuals should take shelter away from glass-enclosed spaces even though the glass is covered with an anti-scattering material.

Photographs showing the vacuum-concussion apparatus used in this investigation and the characteristic breaks which occurred in the different specimens, and a brief description of the materials and treatments studied, are given in this 31-page report. Copies of M175 can be obtained at 10 cents each from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

DETERMINATION OF TIN IN NONFERROUS METALS.

In the analysis of nonferrous alloys, tin is usually determined by titration of a stannous chloride solution with an iodine or iodate solution. This method is subject to a number of limitations. Some of the other constituents in the alloy have an effect on the reaction even when they are present in small amounts. Oxygen dissolved in the solution of oxidant also is said to introduce an error. These errors are usually small and not prohibitive for most commercial work.

A gravimetric method for more accurate work has been developed by William D. Mogermen at the Bureau and will be published as RP1610 in the October *Journal of Research*. The procedure calls for separation of the tin by distillation, precipitation with cupferron, and ignition to stannic oxide. Results obtained by applying the method to known amounts of high-purity tin and to a number of copper-base and lead-base alloys show that an accuracy to ±0.2 mg. may be expected for amounts of tin ranging from 0.05 to 0.24 g.

MACHINES AND METHODS FOR TESTING CORDAGE FIBERS.

Cordage fibers, so essential to military, naval, and civilian purposes, became critical materials soon after the Japanese attack on Pearl Harbor. Every effort had to be made to conserve the available supply, utilize all possible substitutes, develop new sources, and expand the production of the available materials. To effect these measures, machines and procedures for testing cordage fibers in the unprocessed stage were needed for the quick evaluation of the characteristics of experimentally grown fibers and the new native fibers as possible substitutes for abaca (manila), sisal, and jute.

Data concerning the characteristics of fibers long used in the manufacture of rope and cordage were also needed as a basis for judging the suitability of other fibers. These methods and data can be employed in the search for and in the quick development of sources of substitute fibers, and obviate the need of large quantities of fiber that are ordinarily required for test specimens, and that might better be made into rope. The results of this investigation should also aid in the improvement of cordage fibers after the war. They provide means for studying the characteristics of fibers from a single leaf and for conducting systematic and carefully planned experiments.

The development of machines and procedures for testing cordage fibers in the unprocessed stage was undertaken by the Bureau at the request of the Board of Economic Warfare after the Board had consulted experts of the War Production Board and the United States Departments of Agriculture, War, Navy, and Commerce. The proposed study was discussed with experts of the cordage industry. Funds for initiating the investigation were provided by the Defense Supplies Corporation. In addition to the development of machines and testing procedures, the project included tests of standard grades of cordage fibers as well as proposed substitutes.

Machines developed for testing flexural endurance and resistance to abrasion of bundles of cordage fiber are described in a paper by Herbert

F. Schiefer in the October *Journal of Research* (RP1611). In the test for flexural endurance a bundle of fibers having a twist of one turn per inch is repeatedly drawn back and forth over three small pulleys located at the vertices of an isosceles right triangle. In the test for resistance to abrasion a similarly twisted bundle of fibers is drawn back and forth against a second bundle which is twisted once around the first. This test is made in such a way that the flexing of fibers during the test is reduced to a minimum.

The procedures for selection of fibers, preparation of fiber bundles weighing 5 grains per 15 inches of length, and conditioning of test specimens are outlined. The unprocessed fibers were tested for the following characteristics: Fineness of fiber; Dry and wet breaking strength and elongation; Effect of elevated temperatures, continuous soaking in fresh and in salt water, alternate wetting and drying using fresh or salt water, and exposure to light with intermittent spraying with water. The results of tests of 6 lots of abaca, 9 of sisal, 3 of hemp, 2 of jute, 2 of henequen, 1 of pita floja, 1 of ixtle, 4 of sansevieria, 1 of palmetto, 3 of hemp, 2 of roselle, 1 of manzanita, 1 of malvita, and 2 of yucca are given and discussed.

Great variations were found in the characteristics of different lots and grades of one kind of fiber, and results on different kinds frequently overlapped. No one kind of fiber was best in all respects. Abaca was the strongest of the fibers tested, but some of the lots of abaca were weaker than some lots of sisal. Henequen and sisal were more resistant to abrasion than the other fibers, and they had higher flexural endurance, but were the least resistant to exposure to light and intermittent spraying with water. Pita floja, one of the strongest fibers tested, was one of the least resistant to abrasion. Sansevieria had exceptionally good strength. Hemp and jute were very similar in all of the characteristics measured. The resistance to abrasion of all fibers tested was profoundly affected by the direction of twist in the ply relative to that in the bundle, and also by the addition of a small amount of lubricant.

HEATS OF COMBUSTION OF PARAFFIN HYDROCARBONS.

In a paper (RP1607) entitled "Heats of combustion of eight normal paraffin hydrocarbons," by Edward J. Prosen and Frederick D. Rossini of the Bureau's thermochemical laboratory, which appears in the October number of the *Journal of Research*, are reported experimental data on the heats of combustion at 25° C. of n-pentane, n-hexane, n-heptane, n-octane, n-nonane, n-decane, n-dodecane, and n-hexadecane. The calorimetric and chemical apparatus and procedure are described in detail. A following paper in the series will utilize these data in the selection of "best" values for the heats of combustion of the normal paraffins and in the calculation of their heats of formation.

IONIZATION CONSTANT OF BORIC ACID.

The control of acidity and alkalinity of aqueous solutions has long been recognized as important in the manufacture of numerous commercial products. Industrial processes, such as conditioning of boiler waters, removal of suspended and colloidal particles, the formation and the coagulation of emulsions, extraction of alumina from clays, and the inhibition of bacterial growth, depend largely upon pH control. Many of these solutions are alkaline, and uncertainties have entered into the measurement of their pH, because of the lack of reliable alkaline standards.

George G. Manov, Nicholas J. DeLollis, and S. F. Acree of the Bureau, recommend certain borax-sodium chloride solutions as fixed points for the calibration of the pH scale in the alkaline range over the temperature interval 0° to 60° C. A solution composed of 3.814 g. of borax and 1.169 g. of sodium chloride in a liter of solution has a pH of 9.155 at 25° C. and may be used for checking glass-calomel and other electrometric pH equipment.

The theory of the method, the manner in which the chemicals are purified, and the experimental data are given in the October number of the *Journal of Research* (RP1609).

THE FRANKLIN INSTITUTE.

STATED MONTHLY MEETING, OCTOBER 18, 1944.

The first stated meeting of members of The Franklin Institute for the season was held at 8:15 p.m., Wednesday, October 18th, with the President, Mr. Charles S. Redding, presiding. The audience stood at attention for the playing of the National Anthem.

The meeting was then called to order and the Chairman announced that the minutes of the last stated meeting had been printed in full in the June issue of the JOURNAL of the Institute and that they would be declared approved as printed unless some objection was raised. There being no objection, the minutes were so approved.

The president stated that a special meeting of The Franklin Institute had been held at 4 p.m. on Wednesday, September 13, 1944, in Franklin Hall, when the Institute was honored by the Ordnance Distinguished Service Award. The minutes of that meeting will be published in full in the October issue of the JOURNAL of the Institute.

In the enforced absence of the secretary, Dr. Allen, the Chairman called upon Dr. John Frazer, assistant secretary, to make a report.

Dr. Frazer stated that since the last meeting the Institute had lost by death two valuable members: Nathan Hayward, former president; and William M. Vermilye, founder of the Vermilye Medal and Chairman of the National Franklin Committee. Both were members of the Board of Managers at the time of their deaths.

Dr. Frazer reported the following elections to membership since the last report at the May meeting:

Active	187
Non-Resident	14
Associate	129
Student	34
Library Sustaining	9 Companies (representing 285 individuals)
Total	373
Total membership now is	5,374

He next brought before the meeting a proposed amendment to the by-laws to be voted upon by all active and sustaining members present. The proposed change is as follows:

> Article II—Section 4, third sentence, now reads:
>
> "Active members, residing permanently at a distance of twenty-five miles or more from Philadelphia, shall pay annual dues of $5.00."
>
> It is proposed that the above sentence be altered to read:
>
> "Active members, residing permanently at a distance of fifty miles or more from Philadelphia, shall pay annual dues of $7.50."

In accordance with Article X of The Franklin Institute By-Laws, the proposed amendment was presented by two active members to the Board of Managers, which body approved the amendment at its meeting on May 17, 1944.

The Chairman, being assured of the presence of the necessary quota of twenty-four voting members, then asked for discussion and approval.

It was duly moved, seconded and carried that the proposed amendment be adopted.

There being no further business, the Chairman introduced the speaker of the evening, Mr. Samuel G. Hibben, Director of Applied Lighting, Westinghouse Electric and Manufacturing Co., Bloomfield, New Jersey, who spoke on "How Illuminants are Born."

He reviewed in popular science language some of the interesting steps that have been taken which have led to the most recent and some of the near future illuminants. His story centered about the ionization phenomena of metallic vapors and gases. He showed lamps giving off ultra-violet radiations which are used for medical purposes. He also demonstrated cadmium and tellurium vapor lamps, recent laboratory developments.

The meeting was adjourned with a rising vote of thanks to the lecturer for a very entertaining and instructive talk.

JOHN FRAZER,
Assistant Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of Stated Meeting held Wednesday, October 11, 1944.)

HALL OF THE COMMITTEE,
PHILADELPHIA, OCTOBER 11, 1944.

MR. WILLIAM B. COLEMAN *in the Chair.*

The following reports were presented for final action:

No. 3129: Econ-O-Matic Drive.

This report recommended the award of a Certificate of Merit to Walter J. Coppock, of Moylan, Pennsylvania, "In consideration of his design of a novel and theoretically sound motor base which gives automatic belt tension under widely varying load conditions."

No. 3138: Work of Lewis F. Moody.

This report recommended the award of an Elliott Cresson Medal to Lewis Ferry Moody, of Princeton, New Jersey, "In consideration of the leading part he has taken in the design and development of hydraulic turbines and pumps, the many patents issued to him, which have been widely used in practice, due to improvements in efficiencies, higher speeds and better operating characteristics, and his valuable contributions to the theory of design in this field of engineering."

LIBRARY NOTES.

The Committee on Library desires to add to the collections any technical works that members would wish to contribute. Contributions will be gratefully acknowledged and placed in the library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat Service. Photostat prints of any material in the collections can be supplied on request. Orders received in the morning are filled the same day. The average cost for a print 9 × 14 inches is thirty-five cents.

The library and reading room are open on Mondays, Tuesdays, Fridays and Saturdays from nine o'clock A.M. until five o'clock P.M., Wednesdays and Thursdays from two until ten o'clock P.M.

RECENT ADDITIONS.

AERONAUTICS.

DURAND, WILLIAM FREDERICK. Selected papers. 1944.
LEY, WILLY. Rockets. 1944.

ARCHITECTURE AND BUILDING.

American Concrete Institute. Proceedings. Volume 39. 1943. 1944.

ASTRONOMY.

SIDGWICK, J. B. Introductory Astronomy. 1944.

BIOGRAPHY.

FRANKLIN, BENJAMIN. Essays and Letters. Two Volumes. 1821–1822.
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NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

Distribution in the Rat of Injected Radioactive " Muscle Shock Factor " of Green.—J. O. Ely. Much has been written concerning toxic substances originating in injured tissues. The question as to whether toxins are the cause of traumatic shock is uncertain at present. Recently H. N. Green (*Lancet*, **2**: 147, 1943) described the preparation from uninjured muscle of an extract which when injected into experimental animals produced shock-like symptoms. Bielschowsky and Green described the method of preparation of the extract and its fractionation, and also the chemical properties and effective doses of the final fraction (*Lancet*, **2**: 153, 1943). The final product, designated by those workers as "My$_e$", was found to be composed chiefly of adenosinetriphosphate. They expressed the opinion that the shock-like effects produced by the muscle extract were due to the adenosinetriphosphate.

O. Meyerhof *et al* (*Biochemische Zeitschrift*, **298**: 396, 1939) reported that the labile phosphorus of adenosinetriphosphate exchanges readily. Because of this it was considered probable that radioactive "My$_e$" could be prepared from the muscles of animals to which radioactive phosphorus had been administered. It would then be possible to trace the radioactive "My$_e$" after injection into animals. Accordingly rats were given intraperitoneal injections of radioactive sodium phosphate 4 and 3 days prior to using their muscles for the preparation of "My$_e$" according to the method described by Bielschowsky and Green. The "My$_e$" thus obtained was found to be radioactive.

Small albino rats, fasted overnight prior to use, were employed in the experiments. The "My$_e$" was dissolved in 0.9 per cent. sodium chloride solution for injection purposes.

The experimental treatment of the rats is shown in table at top of page 379.

From rats Nos. 1, 2 and 3 the heart, lungs, liver, spleen and one kidney were removed for examination. The tissues were wet-ashed with sulfuric and nitric acids. The measurements of the relative radioactivity of the tissue solutions were made by means of a Geiger-Mueller Counter designed for use with fluids. From the other rats the following additional tissues were used: a sample of blood, the brain, and a portion of the small intestine.

RESULTS.

The values for the radioactivity of the various tissues are relative. For the purpose of comparison the radioactivity of the lungs has been

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Rat No.	Rat wt. grams	Route of injection	mg. of "My$_e$" injected	Vol. in cc. injected	Remarks
1	71	Intravenous	24	0.6	Collapse followed by death in 2 minutes.
2	64	Intravenous	8 8	0.2 0.2	The second injection was made 2–3 minutes after the first. Collapse resulted but it is probable that recovery would have occurred. Killed by a blow on head 2–3 minutes after the second injection.
3	62	Intravenous	16	0.4	Collapse. Apparently would have recovered. Killed by blow on head.
4	82	Intravenous	25	0.7	Collapse. Still breathing but in a comatous state when killed by blow on head 2½ minutes after injection.
5	94	Intravenous	33	0.7	Collapse in 15 seconds. Died in 2 minutes.
6	84	Intravenous	28	0.8	Died in 1½ minutes.
7	147	Intraperitoneal	38	0.9	Killed by blow on head 40 minutes later. The injection caused apparent distressing symptoms, uneasiness, prostration for short intervals.
8	104	Intravenous	radioactive sodium phosphate	0.1	This rat was used in order to compare the distribution of injected sodium phosphate with that of injected "My$_e$." Killed by blow on head 2 minutes after injection.

given a value of 100. The relative values for the whole organs are given in Table I. The relative values per gram of wet tissue are given in Table II.

When "My$_e$" was injected intravenously, a larger quantity was accumulated by the liver than by any other organ. Next in order came the lungs and heart. The spleen, small intestine, kidney, and brain contained comparatively very little. Intraperitoneal injection led to a somewhat different distribution as shown by the data for rat No. 4. The large amount found in the kidney indicates excretion of the radioactive element in some form, not necessarily as "My$_e$", since

TABLE I.

Relative Radioactivity of Organs.

No. 1–6—Intravenous Injection.
No. 7—Intraperitoneal Injection.
No. 8—Intravenous—sodium phosphate.

Organ	Rat No.							
	1	2	3	4	5	6	7	8
Lungs	100	100	100	100	100	100	100	100
Liver	211	141	400	385	517	460	308	225
Spleen	1	0	19	3	3	0	202	6
Heart	15	18	125	65	81	47	146	33
Brain	—	—	—	8	8	0	23	15
Kidney	4	0	25	12	8	0	215	17

TABLE II.

The Relative Radioactivity per gram of Tissue.

Organ	Rat No.							
	1	2	3	4	5	6	7	8
Lungs	100	100	100	100	100	100	100	100
Liver	28	30	91	43	75	64	308	63
Spleen	3	0	5	6	4	0	202	23
Heart	15	26	145	55	86	61	146	68
Brain	—	—	—	4	6	0	23	16
Kidney	6	0	4	14	12	0	215	40
Intestine (small)	—	—	5	2	11	9	75	37
Blood	—	—	—	69	97	126	88	134

40 minutes elapsed between injections and removal of the tissues for examination. The relative distribution of intravenously injected sodium phosphate was similar to that of "My$_c$".

On the basis of unit weight of tissue, the lungs absorbed more of the intravenously injected "My$_c$" than did the other organs. The rapid removal of the material from the blood is shown by the values of the blood of rats Nos. 4, 5 and 6. The longer death was delayed after injection, the greater was the reduction in the "My$_c$" content of the blood. When the "My$_c$" was injected intraperitoneally (rat No. 7) the accumulation per unit weight of tissue was less for the lungs than for the liver, spleen, heart and kidneys.

These results suggest that the reason for the collapse and death of animals injected intravenously with "My$_c$" may be the effect on the lungs of the high absorption of "My$_c$". Whether or not the effect constitutes shock is outside the scope of this report.

BOOK REVIEWS.

Exercises in Second Year Chemistry, by William H. Chapin. (Fourth edition revised by Werner H. Bromund and Luke E. Steiner. 216 pages, illustrations and drawings, 22 × 28 cms. New York: John Wiley & Sons, Inc., London: Chapman and Hall, Limited, 1944. Price $2.00. Paper.

Laboratory manuals as well as text books need revision from time to time in the interest of being up to date in viewpoint, knowledge, method of approach and arrangement of material. The fourth edition of this work has been made to conform to these modern principles. Originally intended to accompany the text "Second Year College Chemistry" by Chapin, the fourth edition of this Manual appears including the above principles. Part I is devoted to experimental physical chemistry and there are sixty-one experiments here on topics involving kinetic theory, gas laws and laws involving change of phase, atomic weights, equilibrium, solutions, colloids, electrochemistry, etc. The experiments which deal with the theory of ionization, homogeneous and heterogeneous equilibrium have been revised extensively in this edition to conform to the modern theory of electrolytes as developed by Debye and Hückel, G. N. Lewis, Bronsted, Milner and others. Part II dealing with quantitative analysis has twenty-one experiments and covers measurement of acids and bases, gravimetric analysis, volumetric precipitations, volumetric oxidation-reduction reactions, electrolytic deposition and electrolytic separations. A few of the longer and more complicated analyses of the previous edition are omitted here; most of those retained have been revised, and both the theoretical background of the analytical methods and the procedures which are involved are discussed in greater detail.

Much emphasis is given to methods of calculation applied in the mathematical treatment of the fundamental theory. The introduction to the work contains much of practical value in experimenting as well as handling results of observations and the report. The book should fit in well in many courses of chemistry.

R. H. Oppermann.

Selected Papers of William Frederick Durand, Reprinted in Commemoration of the Eighty-Fifth Anniversary of his birth. V. P., 22 × 28 cms. The Durand Reprinting Committee, California Institute of Technology, 1944. Price $2.50.

The name of William Frederick Durand is thoroughly known in science and engineering for his contributions and work in marine engineering, mechanical engineering, aeronautics, and the accomplishments of the Bureau of Reclamation.

In 1938 Dr. Durand was awarded the Franklin Medal by The Franklin Institute:

> "In recognition of his notable achievement as pioneer in laboratory research and theory of aeronautics, and of his diversified and distinguished contributions to the sciences of hydrodynamics and aerodynamics, particularly to the advancement of the theory and development of aircraft propellers."

This volume contains some selected papers of which Dr. Durand was author, reprinted in commemoration of the eighty-fifth anniversary of his birth. The papers are essentially of general interest. There are seventeen of them, from a wide range of periodicals covering many topics. The first is "Life History of an Ocean Wave" reprinted from the Sibley Journal of Engineering, April 1896. Others treat on America's air service, science, mechanical engineering, fluid mechanics, etc. Two of the papers were reprinted from the Journal of the Franklin Institute. The reprints are followed by a bibliography of all published works of this great man, arranged according to subject.

There is much in this book in enlightenment, food for thought, and in general contribution for the betterment of mankind.

R. H. Oppermann.

BASIC MATHEMATICS FOR ENGINEERS, by Paul G. Andres, Hugh J. Miser and Haim Reingold. 726 pages, illustrations, 15 × 22 cms. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., 1944. Price $4.00.

It has been said that knowledge begins with the ability to express thoughts in quantities or dimensions. This has no more truth anywhere than in science and engineering. All modern technological developments are based on this ability and would have been impossible without great care and skill in the use of figures. Much depends upon the mathematical training of scientists and engineers. It is for this reason that methods, coverage, terminology and exercises in mathematical texts and instruction are given close and constant attention.

This book covers in one volume the span from the completion of two years high school mathematics to, and as preparation for, a course in the calculus with special emphasis to engineering applications. The elements of differential and integral calculus are included. In all, there are 670 pages of text which start with a study of the fundamental properties of numbers and the operations with them including the use of the slide rule and means for determining the accuracy of results. One of the features of the book is the early introduction of vector algebra and trigonometric functions. In fact the order of presentation of topics throughout the book is somewhat unusual and mixed.

Following the treatment on numbers, simple algebraic operations are taken up with rules for factoring certain simple forms and the handling of fractional forms of algebra. The study of graphs then introduces the variable, and functions are studied—variations and linear. Simultaneous systems of linear equations are studied, and the graphical method used in their discussion. In the introduction to the trigonometric ratios which is next in order the trend leads up to and includes the solution of right triangles. Then it is shown that the trigonometric ratios are functions which can be plotted and there is an explanation of the extremely important property of their being periodic functions. At this point the simple properties of vectors are taken up such as addition, subtraction, and multiplication by a scalar factor. In all of the foregoing matter there was a development of skill in manipulation of certain simple algebraic expressions. Further skill in more complex problems is now the aim, after which another extension of previously presented work is carried forward, namely the use of exponents to real numbers. Closely allied with this is the introduction to radicals, which, with the former, forms the basis of the next section devoted to logarithms, the properties of which are examined. The common and the natural logarithm systems are mentioned. It is shown how the slide rule is constructed on the logarithmic basis, and how the idea of the logarithm is used to simplify the graphs of many curves.

Under the heading of fundamental relations of trigonometry, two kinds of equations are considered, identities and conditional equations. This precedes the treatments on the oblique triangle and the development of operations with complex numbers and with their graphical representations. The progression of the book then is, in order,—linear equations and determinants, quadratic equations and equations of higher degree, the straight line, the circle including a standard form of equation and locus with polar coordinates and parametric equations, equations of the second degree, elements of solid analytic geometry, and finally the elements of differential and integral calculus. An appendix contains much helpful information in the way of tables, etc., and there is a subject index on the back.

The method of approach is clear and the progression is logical and well connected. The application of various parts to engineering is continually pointed out, so that the student is constantly reminded of the importance of the work. Attention could well be focused on this text as a course of essential and practical mathematics. Those who need such a work for home study, and those who have need for a refresher course and reference will find this book valuable.

R. H. OPPERMANN.

PHYSICS OF THE 20TH CENTURY, by Pascual Jordan. 185 pages, 14 × 22 cms. New York, Philosophical Library, 1944. Price $4.00.

The review of the present concepts of modern physics is made under the title of "Physics of the Twentieth Century" because it is the author's belief that the consummated revolution of our scientific knowledge is not to be made retrogressive by future new discoveries, and no matter how far beyond present attainments the future decades lead, the discovery of Planck's quantum of action must in the future also remain recognized as the historical breaking point at which the epoch of scientific research which began with the Rennaissance ended, and a new epoch was opened. With this as a background the story begins with a review of the classical Galilean-Newtonian mechanics, and modern electrodynamics which includes the work of Faraday and Maxwell. Up to this point no mention is made in the discussion of atoms, so at this point under the heading of "The Reality of Atoms" the preliminary thinking of various scientists and their contributions is reviewed leading up to the development of proof of atomic existence. But, it is shown that the field of research received unexpected and new complex stimulation in the discovery of new facts even before real proof of the reality of atoms. In 1900 Max Planck made the discovery that directed atomic research along new paths.

The review does not concern itself with experimental details or with mathematics so that much of the beauty of the picture is not shown. However, the subject is so cleverly composed that the review of the facts are exposed in a fascinating array. This is probably best illustrated in the chapter on the Quantum Theory Description of Nature. The work of Niels Bohr which pointed out that in all individual problems a verifiable close similarity exists between classical and quantum theory despite thin fundamental difference. Contributions of Heisenberg, Schrodinger, Kant are covered. The last chapter is devoted to physics and world observation wherein limitation is made to what is firmly and reliably established. There are two appendixes, the first devoted to Cosmic Radiation and the second to the Age of the World. The book is written on a high plane. It is a good exposition of the growth of physics and the present day position.

R. H. OPPERMANN.

PEACE, PLENTY AND PETROLEUM, by Benjamin T. Brooks. 197 pages, tables and illustrations, 14 × 20 cms. Lancaster, The Jaques Cattell Press, 1944. Price $2.50.

The title of the book implies that petroleum is of vital importance. Despite the fact that, with regard to reserves of petroleum in the United States, there are many optimists and while we are actually producing more crude petroleum than ever before, we are doing so by injurious forced production of most of our oil fields. This means that in these fields there will be an early peak in production followed by a rapid decline. Nor is there any joy to be found in discoveries of new reserves, for these have been very disappointing. It is inevitable therefore that the nation will become dependent on imported oil.

With this kind of beginning the author reviews the improvement of the industry as the demand for petroleum products grew. It was an outlet for the ingenuity of the beginner and chemist. Likewise he covers what may happen in research when there is an imminent scarcity of petroleum—the substitute. The uses of petroleum in peacetime are discussed and its importance in the many branches of war. Later when a comparison is made of the known reserves in the world the author points out that our present situation in the United States should be a warning to us, for from now on we shall be increasingly dependent on imported oil to meet our peacetime demands. Relationship of government and private company interests in foreign oil holdings is treated on, as are international actions. The subject is viewed from all sides leading to the thought that international cooperation after the war will eventually involve a world rationing of such things as petroleum, with quotas, at least to certain nations.

The book is informative, interesting reading.

R. H. OPPERMANN.

THE PHYSICS OF MUSIC, by Alexander Wood. 255 pages, photographs and illustrations, 15 × 22 cms. Cleveland, The Sherwood Press, 1944. Price $8.00.

The nature of music is that the movement in pitch which constitutes melody should proceed by definite and appreciable steps, and not by indeterminate gliding, and that successive notes should stand to one another in a simple and easily appreciated relationship. This definition is the result of penetrating physical inquiry into an interesting, productive and promising field. The story of the application of science to music has not by any means been completely told, but an indication of results is the known importance of acoustic quality of a room when music is rendered. While main principles of design are fully established, there are many incomplete avenues for exploration even in this field. This entire borderland between physics and music is a wide open field in which the cooperation of musicians and physicists may have important results for the future of music.

This book is devoted to that field. It opens with a discussion of the nature of sound, forced vibration and resonance, intensity and loudness, and pitch. Musical quality which enables us to distinguish between two notes produced on different kinds of instruments is next discussed. This involves the remarkable ability of the ear to analyze sounds as in the case of a vocal quartet when sound waves from four sources bombard our ears simultaneously and we can, from the complicated resultant movement of our ear drum, reconstruct the four separate sources of sound and follow any of them at will. The construction and operation of the ear is given in some detail.

A good account is given of the production of tone by various musical instruments including the vibration of strings, organ pipes and sundry other musical instruments. Dissonance and consonance, scales and temperament, the various methods of recording and reproducing sound, and the design of rooms and halls for satisfactory musical tone are other topics presented. There are a great many illustrations, curves and tables, as well as a bibliography, name and subject index.

The presentation is well made and should interest many in diversified lines of endeavor.

R. H. OPPERMANN.

CHEMICAL ENGINEERING NOMOGRAPHS, by Dale S. Davis. 311 pages, tables and illustrations, 15 × 23 cms. New York, McGraw-Hill, 1944. Price $3.50.

A great many engineers, especially chemical engineers, have come to regard the nomograph as a time-saving tool in their work. When a multiplicity of routine calculations are necessary in order to operate a process, or design even a simple piece of equipment, a nomograph gives quick assistance. The author of this book has been foremost in constructing these nomographs, and his work, together with that of others, has been scattered in technical literature for a period of fourteen years.

The purpose of this book by Davis is to present the nomographs and alignment charts by him and others in a compact and readily usable volume. In it can be found about 200 charts and descriptive and instructive matter dealing with a wide field of chemical engineering interests. The charts themselves are well shown, some of them of surprising flexibility and scope. All are well indexed and are large enough to be read easily. They are supplemented with a text including tables and formulas indicating their validity, application, and limitations with directions for their use. The book is a very handy volume of useful tools.

R. H. OPPERMANN.

SYSTEMATIC INORGANIC CHEMISTRY, by Don M. Yost and Horace Russell, Jr. 423 pages, drawings and illustrations, 16 × 23 cms. New York, Prentice-Hall, Inc., 1944. Price $4.60.

A text on this subject now is of importance ranking with the highest. It is a science in which all of the modern developments of physics and chemistry find application. Reasonable expectations for the future are good, and any text to be useful, must present the present knowledge in such a way and coverage as to point to the future.

The topics presented in this book partly form the basis of the senior and graduate courses in inorganic chemistry given at the California Institute of Technology. They are devoted to the inorganic chemistry of the nonmetallic elements of the fifth and sixth groups of the periodic system. These elements and their compounds, besides being of great practical and theoretical interest in themselves, exhibit in their properties and reactions, characteristics that are common to many other substances both inorganic and organic. There are eleven chapters to the work starting with nitrogen and its oxides and sulfides, and proceeding through nitrogen oxyhalides and oxyacids with a discussion on the fixation of nitrogen, hydroxylamine, ammonia, phosphorus, the oxyacids of phosphorus, phosphorus halides and oxyhalides, oxygen, sulfur, selenium, hydrogen peroxide.

The method of treatment of each topic is generally in the order of method of preparation, physical and chemical properties, constituents or combinations, etc. References in the text are frequent and in the discussion there is enough of both the old and new chemistry to bring out the most important features of the substances examined. The work abounds with formulae, tables, and curves. There is a bibliography of reference books in the back with appendixes of useful information. A subject and author index completes the work.

The text is a useful tool for its purposes within its span of coverage.

R. H. OPPERMANN.

EXPERIMENTAL SPECTROSCOPY, by Ralph A. Sawyer. 323 pages, photographs and illustrations, 16 × 24 cms. New York, Prentice-Hall, Inc., 1944. Price $3.75.

Spectroscopy has emerged from the discovery stage to one of active and important application. In certain fields of research, and in pure research spectrographic methods and equipment are in great demand. For astronomy, the spectrograph, the spectroheliograph, and the new spectroheliokinematograph are among the essential instruments. In physics and chemistry, and the applied sciences its use has been rapidly increasing, so that today a knowledge of spectroscopy is an invaluable aid to many workers in the laboratory.

The book at hand has for its purpose a coverage of prism and grating spectrographs and the techniques of their use in research. Designed for students and for those in research laboratories who wish to make use of spectroscopic procedures, it avoids extensive mathematical treatments so that a background of general physics and some physical optics are sufficient for understanding. It opens with a sketch of the outstanding steps in the development of spectroscopy from the earliest times. The beginning of the text proper is on light sources covering some of the general features and some details of their behavior. This is followed by a discussion of apparatus, the theory and construction of prism spectroscopes and spectrographs, the various types and their uses. The diffraction grating which has replaced the prism in many applications is next taken up. The theory and production is discussed in considerable detail.

Extensively discussed in a practical vein are the important topics of photographic procedures, the determination of wave length, and the determination of spectral intensity. Attention is then given to the reason beyond the photographic limit—the infra-red region where the treatment is more brief as it is on the ultraviolet. The last division of the book is devoted to spectrochemical analysis where it is shown that the applications of qualitative analysis are varied and that the method has great advantages of speed and simplicity. In the back are name and subject indexes.

An outstanding feature of the book is the clarity of presentation. It follows a logical procedure. The book furnishes a good background for work in this field and for further studies.

R. H. OPPERMANN.

ELECTRONICS TODAY AND TOMORROW, by John Mills. 178 pages, 14 × 21 cms. New York, D. Van Nostrand Company, Inc., 1944. Price $2.25.

Of recent years there have come into greater prominence a number of authors whose work has been to translate the technical achievements of our time to the language of the layman, proceeding on the theory that as science becomes of more import in every day life there is a proportionate need for more understanding. There is much evidence today that such knowledge is of value, in fact in many cases an intelligent person is measured on his general knowledge of modern scientific things. And the need of the future still points in the direction of practical useful knowledge as well as a broad acquaintance for the purpose of a more thorough appreciation.

The author of this book for many years has made it his work to write technical books for the layman. Electronics Today and Tomorrow is his latest. This book describes the basis, the development, the products, and the uses of electronic devices. It is not a text, nor is it an easy way to become an electronics expert. But it is a well written, plain language exposition of the physics involved in this interesting field of endeavor, to the end that a sound understanding can be had to enable anyone to appraise the present state of the art and to carry on an intelligent conversation about it. The method of presentation has been well thought out and the progression from electrons through electron tubes and electronic devices is logical, well connected, and fascinating. Anyone not familiar with the subject would do well to read this book and become familiar with it.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

Uses and Applications of Chemicals and Related Materials, Volume II, Compiled and edited by Thomas C. Gregory. 459 pages, 16 × 23 cms. New York, Reinhold Publishing Corporation, 1944. Price $9.00.

History of Color Photography, by Joseph S. Friedman. 514 pages, illustrations, 24 × 16 cms. Boston, The American Photographic Publishing Company, 1944. Price $10.00.

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CURRENT TOPICS.

ARMY AND NAVY NOTES.

Unbroken Seamless Tube Manufacture.—A continuous injection molding and extruding machine, the only known device of its kind in the world capable of laying an unbroken seamless tube of any kind of plastics or rubber from New York to San Francisco, has been developed by engineers and technicians of Chrysler Corporation.

One of the machines is producing seamless plastic tubes to launch deadly rockets, and another one is ready to mass produce rubber insulators. An experimental machine in the Corporation's Engineering Division has produced hundreds of plastic and rubber parts and articles.

The machine has produced as large an item as a plastic battery case in less than five minutes, using 128 ounces (eight pounds) of thermosetting plastics. No other machine is known capable of injection molding an article of this material weighing more than 36 ounces. It has produced at one molding, in less than three minutes, as many as 144 insulators. It is also capable of producing precision rubber parts for airplane motors, and other war products. In the tubing field the machine has enormous possibilities. Thermosetting plastic tubes, made in any lengths desired, can be used for overhead and underground pipe lines. The plastic is highly resistant to corrosion, and in some cases can replace steel and iron pipes with lesser resistant qualities. Where long lengths of iron, steel or concrete are necessary for rigidity, thermosetting liners produced by the machine would provide resistance to corrosion.

The continuous injector consists of a simple hopper holding plastics or rubber. The materials are fed to a heating cylinder where a special churning apparatus keeps them evenly mixed. The putty-like substances are then shot under screw pressures up to 22,000 pounds per square inch through a nozzle clamped to an opening where the dye plates join. When the plastics, or rubbers, have filled every tiny crevice in the mold, or series of molds, the back pressure automatically shuts off the feeder and the worm screw reverses itself, keeping the materials remaining in the heating and feeding chambers pliable and ready for the next injection.

R. H. O.

Fireproof Fiberglas Draperies.—Elimination of a serious fire hazard in places of public assembly has been made possible by development of new processes for dyeing and printing decorative fabrics woven of incombustible glass fibers, Leon Chastel, manager of Thortel Fireproof Fabrics, New York, said recently at the Institute on Textiles and Clothing held at Michigan State College.

The title of Mr. Chastel's talk was "Fiberglas Draperies: New Colors, Designs and Weaves in Fireproof Fabrics." The Institute is being held under the auspices of the College's Division of Home Economics and is attended by college teachers and extension service workers in home economics.

Referring to such disasters as the Boston night club fire, the burning of the Morro Castle, and the Iroquois Theatre fire, Mr. Chastel said that for many years it has been recognized that inflammable draperies aboard ship and in schools, theatres, restaurants, night clubs and hotels have contributed to the toll of life and property taken by fires in such places. Methods of flame-proofing inflammable fabrics have not eliminated the hazard, he said, partly because the effectiveness of the treatment depends upon the skill of the flame-proofer, and partly because the flame-proofing must be renewed at regular intervals, involving a recurring expense.

Fiberglas fabrics, Mr. Chastel pointed out, were produced as long ago as 1936 and are widely used for industrial and war purposes. But because no means was found to make dyes adhere to the glass, their use for decoration has always appeared to be limited. Color could be added to the molten glass batch, but satisfactory effects could be produced only in pastel shades. It is now possible to dye the fabrics in many brilliant solid colors and shades. Stripes, figures, and prints have been developed in a variety sufficient to meet all decorative needs.

"In weight most of these Fiberglas materials compare with damask or heavy satin. They fall into attractive folds, but do not retain wrinkles. All of them can be dry-cleaned, and the whites can be laundered and ironed. Because they are made of glass they are mothproof. For the same reason, they will not rot or disintegrate under the severest climatic conditions; nor will they stretch or sag under changes in humidity. Their colors are fast to sunlight and cleaning.

"The fire-safe feature is so important in places of public assembly that the probabilities are that these places will always be the chief users of glass decorative fabrics. Certainly this will be true during the period of the war, for there are many war uses that have first call on Fiberglas materials. What remains is no more than is required to make a start towards eliminating one of the great hazards in places where large numbers of people congregate.

"In the home, the feature of fire-safety is of lesser importance, for there is not the same danger of mass panic that there is in a theatre, night club or school. Glass decorative fabrics do, however, possess many other features which may lead to their wide use as drapery materials in the post-war home—particularly in seashore homes where salt air and strong sunlight play havoc with the more familiar drapery materials, and where high humidity often causes other materials to stretch and sag.

"The extent to which Fiberglas fabrics will be used for other decorative purposes in the home cannot be clearly foreseen at this time. They are not suitable for use as upholstery fabrics or for other applications where they would be subjected to friction—this, by the way, rules out the use of glass fabrics for wearing apparel."

R. H. O.

Ordnance Repair and Replacement System.—(*Army and Navy Register*, Vol. 65, No. 3379.) Ordnance Department combat mechanics are making an invaluable contribution in sustaining the striking power of the swift American offensive in France. Lieut. Gen. George S. Patton's Third Army reached Paris with almost the same number of tanks and armored vehicles with which he began his spectacular drive down the Normandy peninsula because of the efficiency of the ordnance repair and replacement system.

Some of the General Sherman tanks covered more than 600 miles in two weeks—an average of over 40 miles a day. One tank column traveled 96 miles in 24 hours, and another sped forward more than 100 miles in 12 hours. The fast moving armor of the Third Army gained ground so fast that Corps and Army headquarters had to send artillery scout planes forward to check where they were. So quickly did the tanks slash through the Germans that the enemy had no opportunity to re-group or organize a new line.

Ordnance men follow closely in the wake of Gen. Patton's fast moving columns. They establish temporary tank parks where new tanks are held in instant readiness to be put into the fight the moment the tank already in action is shot up or otherwise seriously disabled. These spare tanks are moved forward as the battle progresses. They are never more than four or five miles behind the fluid battle front. Damaged tanks are hauled to the rear on giant tank transporter vehicles where ordnance men patch them up as quickly as possible.

When only minor breakdowns occur, ordnance personnel give Gen. Patton's tankmen curb service repairs from speedy shop trucks. These 2½ ton, six-wheeled trucks, containing all the equipment and spare parts of the most modern repair shops, are constantly employed to make on-the-spot repairs on a 24-hour basis.

Just prior to D-Day, hundreds of ordnance troops in England tuned up tanks and other combat vehicles. At one ordnance base shop alone, soldier welders, machinists, blacksmiths, and mechanics labored 165,000 man-hours to complete the job before D-Day on more than 1,000 tanks subsequently used by Gen. Patton's Third Army.

R. H. O.

Yellow is the Color.—Commander FREDERICK J. NELSON, U. S. Navy. (*United States Naval Institute Proceedings*, Vol. 70, No. 498.) Somewhere in the blue above the clouds and high over a convoy zigzagging along the coast line, some Lightnings shot down a German "snooper." The Convoy Commodore knew that there were enemy planes in the vicinity but he had no knowledge of the fray aloft until a lookout on an escort vessel sighted an object in the water—a small yellow area which stood out in clear contrast against the dark background of the rough blue-black waters. Visual signals flashed, an escort was diverted, and the captain, guided to the spot by the contrasting color of the floating object, picked up an enemy pilot in a yellow rubber raft.

Aviation has long recognized and used the "good seeing" and contrasting qualities of the various shades of yellow. Our highway engineers also recognize this property of yellow.

The white light emanating from the sun is radiant energy consisting of different wave lengths. Only a small range of the solar spectrum is visible to the human eye—the band between 6,800 Angstrom units (the reds) to about 4,000 units (the violets). The white light which the earth receives from the sun is a mixture of all the spectrum colors. On passing through our atmosphere it is subjected to scattering by the particles in suspension in the air with the result that the human eye always sees the sky as a shade of blue.

Water has no color, but when sunlight strikes the sea, additional scattering takes place due to the suspended matter in the water. Thus, the sea usually appears in deeper coloring than the sky.

There are several theories which attempt to explain color vision. The Young-Helmholtz theory assumes that there are three sets of color-perceiving elements in the retina, each of which is singularly sensitive to one of the primary colors—red, green, and violet. If light entering the eye stimulates only the end organ sensitive to red, green, or violet, the resulting color sensation is red, green, or violet depending upon which end organ is stimulated.

When light strikes a yellow surface, all the visible colors in the spectrum are absolved except the yellow, which is reflected. When the yellow light strikes the retina, it stimulates the red and the green color perceiving elements and the combination of these two sensations registers as a yellow color. The cause of total or partial color blindness has not been determined, but it is known that though red-green color blindness is relatively common, blue-yellow color blindness is so rare that it might almost be disregarded.

Not only is yellow a good contrasting color against a dark background, but the human eye has its maximum color sensitivity at 5,500 Angstrom units. The yellow sodium line has a wave length of 5,800 Angstrom units and fades into lighter yellows as the wave length decreases. Thus, it is readily seen that the use of yellow as an outstanding color for "good seeing" has scientific support, for normally it is not only the easiest color to see but because blue-yellow color deficiencies are rare, more people can see it.

R. H. O.

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Production of 100 Octane Gasoline.—(*Army Ordnance*, Vol. XXVII, No. 145.) Production of 100 octane gasoline, a super fuel which our combat planes must have to exert supremacy over the enemy, has increased by more than 400 per cent. in the last year and a half but is still far below the ultimate needs of America's fighting forces, according to the Petroleum Administration for War. Before many months, production will be about eight times greater than in the spring of 1942. Even this quantity will be below minimum needs when further planned expansion of the air forces is accomplished.

Altogether about $900,000,000 is being invested in production facilities for 100 octane gasoline, the program exceeding that for synthetic rubber in both size and cost. More than seventy-five per cent. of the cost is being borne by the oil companies.

In addition, technologists discovered how to get 4.2 gallons of 100 octane gasoline from every barrel of crude oil. Previously the yield was .21 of one gallon. The result of this process is less automobile gasoline from the barrel. Due to the cracking process used to get 100 octane gasoline, less heating oil is also obtained from the barrel of crude.

As recently as 1933, 100 octane was a laboratory curiosity. At that time it would have cost sixteen dollars a gallon. The first 100 octane sale made to the Army in 1934 was at two dollars a gallon. Today, 100 octane is bought by the Government at less than fifteen cents a gallon.

The exact figures for the increased performance of military planes using 100 octane are secret, but the Navy has released the following figures for a twin engine commercial transport plane: using 87 octane gasoline, the plane needs

2,400 feet for take off; with 100 octane it needs only 2000 feet—a reduction of 16 per cent. With 87 octane it can climb 1,000 feet a minute; with 100 octane, it can climb 1,400 feet a minute—an increase of 40 per cent. With 87 octane, it can cruise at 176 miles an hour; with 100 octane, it makes 191 miles a hour. With 87 octane, its surface ceiling is restricted to 22,000 feet, but this is lifted to 28,000 feet by the use of 100 octane fuel.

R. H. O.

Checking the Angles.—(*Modern Plastics*, Vol. 22, No. 1.) One of the most important tools of the ground crew of any plane, large or small, is the propeller protractor. Designed to determine, while a plane is on the ground, the angle of pitch of the propeller and to synchronize this angle on all the propellers of a multi-engined plane, the instrument is also used for various other purposes. These include checking plane elevators and all other parts where the exact relation of the angle of one part to the angle of another or to the ground, level or sloping, must be known.

Originally, propeller protractors were made entirely of aluminum, but early in the war it was feared that a scarcity of this metal might hamper production. Since the devices are so essential that at least one is needed for every ground crew, development work was begun, two years ago, on a plastic protractor. Now all the initial difficulties encountered in the intricate molding and assembly operations have been overcome and the unit is being supplied in quantity to the Army Air Force.

In design, size, and general construction, the plastic protractor is practically a replica of the aluminum device. It is 7 in. wide and a little more than 7 in. high with a 4½ in. handle on the back. Altogether there are 8 component parts which are molded of high acetyl acetate; the base, 2-piece fine lycalibrated dial, front dust protector, handle, front indicating level and two small brackets.

Probably the greatest advantage of the plastic protractor is the accuracy of the calibrations and the thinness of the calibrating lines. Dial dies having the utmost precision are responsible for this accuracy and make possible the production of many dials possessing the same exactness of calibration. In contrast, each aluminum dial had to be individually engraved.

The dial pieces are fitted with greater precision. Specifications for both the plastic and aluminum instruments allow a "play" of only 5 mm. in one degree. While this play in most metal protractors is about this limit, in the plastic devices, it is, on the average, much less. The plastic dials have also made possible a considerable saving in man-hours of of labor.

During the two years of experimental work, a number of different plastics were tried. It was found that high acetyl acetate stood up most satisfactorily under the required temperature cycle of -58 to $+158$ deg. F.

As a test under conditions of usage, an Army mechanic using the instrument in a large plane hangar, dropped it 60 feet. Although the glass in the levels was broken and the squareness of the edges impaired, none of the parts were jammed. The protractor was still workable, and there was little interference with accuracy.

R. H. O.

Care of Synthetic Rubber Tires, Tubes, and Tracks.—(*Army Ordnance*, Vol. XXVII, No. 145.) New and critically important installation procedures characterize the new bulletin of the Office of the Chief of Ordnance, Detroit, to inform the Army on its new synthetic rubber tires, tubes, and tracks. Publication of the bulletin was initiated by the Maintenance Division of the Army Service Forces. The relatively brief technical bulletin, TB 31-200-1, disseminates immediate information to the field.

Practically all new tires, tubes, and tracks going into service are manufactured wholly or in part of synthetic rubber. The bulletin stresses the fact that they have special characteristics because of their synthetic nature, and consequently several standard procedures of installation have been revised, particularly with respect to synthetic tubes.

The bulletin calls particular attention to the extra care that must be given to maintaining correct tire pressures. Under-inflation is more harmful to synthetic rubber than it is to natural rubber. The flexing action in the side walls that results from under-inflation sets up a relatively higher temperature in the synthetic product, and the higher temperature causes damage. It is equally important that over-inflation be avoided, since excessive pressures make the tire more susceptible to bruises and hasten wear.

The bulletin is based on a statement which has the concurrence of S. P. Thacher, Chief of the Rubber Branch, Production Division, Army Service Forces.

When installing synthetic tires, rims must be thoroughly cleaned, all grease and grit, scale and rust must be removed. Dual tires and driven tires must not vary more than ¾ inch in circumference or ¼ inch in diameter. When inflating tube before inserting it in casing, do not inflate beyond a point where it rounds out. Synthetic tubes do not slip into position as readily as natural rubber tubes. For this reason it is imperative that the tube be completely dusted with talc or soapstone before installation. When flaps are used, they must be dusted with talc or soapstone, and they must be installed carefully so that they are well centered and free from wrinkles. When tires are mounted on a drop-center rim, be sure the tire beads are out of the rim well before inflating. If they aren't, the tube may pinch and tear. Inflate tube partially to pull tube and casing into approximate position. Then inflate to proper pressure. This new 2-step inflation procedure is of vital importance.

R. H. O.

Torquemeter.—(*Scientific American*, Vol. 171, No. 3.) A "magnetic tailwind" that will enable American bombers to reach targets 100 miles or more beyond their present range has been developed at the Westinghouse Research Laboratories. The "tailwind" is a new magnetic coupled torquemeter which makes it possible for a bomber pilot to determine the power output of his engines 10 to 15 times more accurately than with the method now commonly used. With this precise information, it is easy to adjust the engines to achieve maximum fuel economy, squeezing 5 to 10 percent. more miles out of each gallon of high octane gasoline.

The torquemeter conveys its information to the pilot by measuring the "twist" in the hollow steel shaft connecting a bomber engine to its propeller. The amount of twist—it may be only a few thousandths of an inch for a distance of several inches along the shaft—is an accurate measure of the driving force delivered to the propeller by the engine.

Vital part of the torquemeter is a stationary metal sleeve and coil assembly which encircles the propeller shaft. Projecting from rings on the propeller shaft are two sets of gear-like teeth whose faces are a few thousandths of an inch apart. As the propeller shaft twists under load, the relationship between these teeth changes. Invisible magnetic "fingers" extending across the gap between the metal sleeve and the shaft detect this change and report it electrically to the dial on the instrument board. The torquemeter enables the pilot to figure an engine's horsepower within 1 or 2 percent. With this knowledge he can adjust each engine's throttle, fuel-air ratio, and propeller pitch so all engines are delivering power at the same rate and at peak economy.

Other magnetic torquemeters are destined for use in the laboratories where new types of aircraft, truck, and tank engines are being developed and in naval laboratories, where engineers need accurate measurements of the power transmitted by a ship's propeller shaft, a set of reduction gears, or a whirling turbine.

R. H. O.

Steel Fabricated Barges With Refrigeration Plant Shipped in Knockdown Packages Serve as Food Carriers in Battle Zones.—FRED A. HERR. (*Ice and Refrigeration*, Vol. 107, No. 3.) Designed to serve as refrigerated floating food warehouses for storing and preserving perishables in the far flung battle areas of America's war program, mass production of a unique type of steel fabricated barge equipped with Freon gas refrigerating systems, has swung into full production at the plant of the National Iron Works, San Diego, Calif.

Development of the barges, for which there is believed to be no precedent in the refrigeration field is the result of the combined efforts of Army engineers and the engineering staff of the National Iron Works.

The several hundred different parts that make up a complete barge are manufactured or assembled in the firm's San Diego plant, then shipped in packaged form to their destinations in the war zones. One barge requires 368 individually packed shipments, and 10 railroad box cars and gondolas are needed to move the packages from the plant to ports of embarkation for shipment overseas. Upon arrival at the island base to which the packages are consigned, the different parts are bolted together in the field according to specific directions which accompany each shipment. Items for facilitating assembly in the field are shipped along, such as cement, gaskets, grommets, etc., and paint for painting the vessels after they have been assembled. Dimensions of the barge hulls are: length 104 ft., width 29 ft., depth 8 ft. The hull is flat bottomed. The deckhouse measures 85 ft. in length, 22 ft. in width and 8 ft. in height, on top of the deckhouse being mounted a four-man crew's quarters, 15 by 17 ft. in dimension.

A complete refrigeration system is shipped in separate packages as part of each barge. The cooling system equipment includes fire lines, circulating water lines, oil lines, electrical control and alarm circuits, condensers, receivers, coils, etc.

These barges are designed for service as food carriers in the battle zones, chiefly in the South Pacific area, where supplies must be carried hundreds of miles along the ocean lanes as the frontier of the United Nations moves toward the Nipponese strongholds in the Philippines and on the Asiatic mainland. The barges weigh about 180 tons, have a cargo capacity of about 400 tons, and can operate without refueling or rewatering for three successive months.

R. H. O.

Ford Electronic Camera For Surface Analysis.—(*Automotive and Aviation Industries*, Vol. 91, No. 5.) Important postwar applications in determining why some bearings give much longer service than others of the same apparent quality are predicted by Ford Motor Co. laboratory engineers for the new diffraction electronic camera recently installed for test purposes. Built by the University of Michigan engineering department, the machine already has proved its merit by determining why aluminum from some sources gave difficulty in obtaining uniform spot welds on parts of the B-24 bomber, although of the same composition as satisfactory shipments from other sources. Specimens were placed in the machine and a stream of electrons shot against the surface to be analyzed. The varying patterns photographed on the sensitized glass plate of the camera were identified as different oxides deposited on the metal during processing. Each of the oxides presented a different degree of resistance when placed in the welding machine, but when adjustment of the welder was made to conform to the particular oxide, no further difficulty was experienced in making the weld.

The camera quickly and accurately analyzes surfaces as thin as one millionth of an inch, providing ready identification of surface oxides and other film deposits too thin to yield samples for chemical analysis. Although little work has been done with it as yet on bearing life, Ford engineers forecast an important part for the camera in this field. It will be used first to investigate the chemical and physical changes that occur in bearing surfaces after a test run. It then will be used to determine what chemical or physical treatment is necessary to produce a long-wearing surface or to change the molecular structure of the metal to give long life.

The machine also is useful to identify corrosive deposits left by degreasing agents or other metal cleaning compounds. It was found at the Ford plant that a chemical used to remove anti-welding oxides left other oxides equally undesirable. Suitable chemicals were tested with the camera and catalogued, resulting in improved welding.

R. H. O.

Rocket Power Used to Aid Plane Take-Offs.—(*Steel*, Vol. 115, No. 12.) Rocket power is successfully helping heavily laden planes into the air, according to the AAF Materiel Command, Wright Field, Ohio. Despite the successful nature of the tests, these take-off units probably never will see tactical use as Materiel Command engineers have found such use extremely limited.

Originally developed as a means of lifting heavy loads into the air from short, front line runways, the rocket take-off units are capable of doing their job. Front line reports, however, indicate that short runways are hazardous for planes returning from a mission, not because of load but because crews were fatigued and planes often shot up or crewmen wounded. Consequently, longer runways were planned from the first in an effort to cut down the number of landing accidents.

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The Germans are reported to have placed such take-off units in tactical use. A possible explanation lies in the high altitude propeller used by the Luftwaffe. This "prop," designed for flight at high altitudes, hampers take-offs.

German rocket experiments had been carried on for several years when the AAF launched its own intensive experiments in 1940. The Germans first used rocket power for propelling gliders.

As opposed to the jet propulsion engine, which takes its oxygen from the air, a rocket carries its own supply—making rockets theoretically capable of flying above the oxygen level. Rockets carry both fuel and oxygen. Early experimenters used gasoline and pure liquid oxygen. The burning fuel expands and is thus forced through a nozzle at the rear, giving the plane a forward push—the same effect achieved in another way by jet propulsion.

Materiel Command experts faced two major problems—suitable fuels and oxidizers, and a nozzle which would stand the terrific heat of the ignited gas. This latter problem has been solved. Better combinations of fules and oxidizers still are being sought.

Two types of take-off units were developed, the fixed and the droppable. Attack planes were equipped with the fixed type, with the nozzle emitting the gaseous flames from the rear of the engine nacelle. Other, heavier planes, were equipped with droppable rockets attached to the underside of the wings. This type could be dropped by parachute and salvaged for use again. The rockets are designed to operate until the plane is air-borne and the landing gear has been retracted.

Although the tactical utility of the take-off units has been proved negligible, rocket experiments continue, with emphasis on sustained rocket flight, long a dream of pseudo-scientific fiction writers. At the current stage, such rocket engines are relatively ineffective.

R. H. O.

Aerosol Bomb Used in Alaska.—The post-war value of the aerosol bomb in combatting mosquitoes is emphasized in a report by H. H. Stage, U. S. Department of Agriculture entomologist, who has returned from Alaska after two months' investigation of the pests there. Because the mosquito is such a serious pest in Alaska, it has been a good proving ground for ways to protect soldiers against mosquitoes. The "bomb," invented three years ago by Department workers, is not yet available to civilians, although used by the military forces in pup tents, in barracks and in transport planes wherever mosquitoes are found.

Against the Alaskan pests, which need to be at least partially controlled for post-war development of that area, Stage tested several insect repellents developed for the protection of the armed forces by the Orlando, Florida, laboratory of the Department's Bureau of Entomology and Plant Quarantine. These tests, which were conducted for the Surgeon General's Office of the U. S. Army, included also trying out certain kinds of fabric for use in mosquito-proof clothing.

To make a survey of the abundance and kinds of mosquitoes, Stage traveled to practically every part of the Alaskan territory. One of his experiences illustrates how the aerosol bomb is being tested. A small plane landed at an air field northwest of Nome. Mosquitoes swarmed into the plane, causing alarm and discomfort to the passengers. The pilot released a little gas from the bomb, inside the plane. Within a few minutes, thousands of mosquitoes were killed and the passengers returned to Nome without further annoyance.

The aerosol bomb was invented by a chemist, Lyle D. Goodhue, and William N. Sullivan, now a U. S. army captain, then entomologist of the Department's Bureau of Entomology and Plant Quarantine. It is an insect poison "gas" dispenser—a small metal container which holds pyrethrum or other insecticide dissolved in Freon, a common refrigerant, under pressure. When a small valve is opened, the Freon forces the toxic material out in fine spray. The Freon evaporates and the insecticide, toxic to some insects but not to man, floats in the air in tiny droplets. Not actually a gas, these droplets form a fine suspension or invisible fog.

To release enough of the poison to kill mosquitoes in a room of 2,500 cubic feet takes only 10 seconds. In addition to household use, after the war, against mosquitoes and flies, entomologists say that the aerosol dispenser method looks promising for protection of certain truck crops as well as to protect those living or traveling where mosquitoes abound.

R. H. O.

Whey for Penicillin.—Little Miss Muffett, who sat on a tuffett eating her curds and whey, must have been well fed, because whey—although almost an orphan among U. S. dairy products—is nutritious.

A byproduct of cheese and also of casein, whey contains about half the solids of whole milk, the War Food Administration reports. It is rich in protein, riboflavin, vitamin B-one, calcium, phosphorus, and milk sugar—or lactose. This milk sugar has gained importance. Scientists find that the mold which excretes penicillin—the miracle drug—grows well in a milk sugar culture.

Until this year, most of the whey produced here was used as animal feed, and quantities went to waste—especially cheese whey which had too little commercial value to pay factories for salvaging it. Milk sugar for infant foods, pharmaceuticals and a few other purposes came mainly from casein whey.

However, just about the time penicillin manufacture required quantities of milk sugar, casein whey production declined. With urgent need for milk powder by our military forces and our allies, it had seemed more desirable to import more casein and to use skim milks for milk powder. So manufacturers turned to cheese whey as raw material for milk sugar. Cheese whey production has been mounting steadily since early 1941 as a result of Lend-lease, and later U. S. military requirements for cheddar cheese.

To encourage salvage of cheese whey, WFA recommended higher ceiling prices for whey products, and cheese factories found it profitable to save whey for processing.

The output of milk sugar has been practically doubled within a few months. Production is now sufficient for all needs in prospect—including penicillin—and WFA finds it is no longer necessary to allocate milk sugar.

R. H. O.

Steel Productive Capacity.—Disregarding war damage, the steel capacity of the principal steel manufacturing countries of the world stood at 207.4 million tons in 1943, an increase of 23 million tons as compared with the peacetime year of 1938, reports THE INDEX, quarterly publication of The New York Trust Company, in an analysis of the peacetime prospects of the American steel industry. The United States was responsible for 15 million tons, or more than two-thirds of this expansion, it is stated.

Never in their history, the survey holds, have the export divisions of our steel companies faced a greater opportunity and obligation, although steel exports cannot be estimated conclusively until the industry knows the rules under which it will be forced to operate and the extent of war damage abroad. The report continues in part:

"In both the World Wars, American exports of finished steel products have played an important part. Because of the demands of our Allies, or of countries who became our Allies when this country actively entered war, shipments expanded rapidly. In 1916, for example, exports were 6.6 million tons as against 1.7 millions in 1914. They exceeded the 7 million mark in 1917, stood at approximately 6 millions the following year, and then began to decline. But peacetime exports for the average decade from 1920 to 1929, inclusive, averaged only about 2.6 million tons.

"Our exports of finished products reached a low point, for the past thirty years, of 423,825 tons in 1932 and the average for the decade of the 30's was only 1.7 million tons. In 1940, however, we shipped 8.7 million tons abroad —6 millions more than the previous year—largely because of the war requirements of the United Nations, and in 1941 exports stood at approximately 7 million tons. Figures for succeeding years have not been made public.

"It is confidently expected by experienced steel executives, who have been sponsoring careful post-war studies, that exports for the first and second years after the war will be comparable to 1940 and 1941. For the period comprising the third, fourth and fifth years after the war, however, these leaders look for exports to fall to an amount ranging between 3 and 4 million tons."

The steel companies have studied peacetime prospects of the industry's largest customers, according to the survey, and envisage an increased demand for steel in many leading fields such as housing, agriculture, railroads, the motor industry and highways.

"While all indications are that steel will continue to be a 'prince or a pauper' industry, THE INDEX concludes its current financial strength, the outlook for steel orders, and the extraordinary technical progress made by manufacturers during the war augur well for a post-war period more promising than that which followed the first World War."

R. H. O.

Dehydration Meat Reduces Weight and Bulk Two-Thirds.—The dehydrating of meat, in experiments conducted by the U. S. Department of Agriculture, reduced the weight 60 to 70 per cent. Subsequent compression of the product for packaging reduced the volume 65 to 73 per cent. Thus the savings in both weight and bulk were approximately two thirds, based on the original quantity of boned and trimmed meat.

These results—together with a description of eight methods of dehydration and their effect on the nutritive value, palatability, and other qualities of dehydrated meat—are presented in a report of the experiments, sponsored by the Department's Agricultural Research Administration. The studies were conducted, as a special wartime project, by a committee of Department meat specialists, engineers, chemists, nutrition workers, and other scientists working in cooperation with the American Meat Institute, the University of Chicago, and other agencies. O. G. Hankins of the Bureau of Animal Industry was chairman of the committee, which worked under the direction of E. C. Auchter, research administrator. Some of the significant results of the studies were as follows:

Of the eight methods of dehydration tested, the vacuum rotary process—so-called from vacuum drying and rotary agitation of the meat—appeared to combine the most good points. Other processes excelled in certain respects, such as rate of drying, continuous operation, or palatability of product.

Dehydrated raw meat, as removed from the drier, was generally a better product than dehydrated cooked meat but offered a problem in keeping quality that requires further study. Precooking the meat improved its ability to keep without refrigeration and was a part of most of the processes. Meat for dehydration should be perfectly fresh.

Studies of packaging and storage showed metal cans to be the best containers for dehydrated meat that must be stored for long periods without refrigeration.

Conditions of processing, packaging, and storage that reduce exposure to air helped in obtaining good keeping quality.

Dehydrated meats canned by the vacuum-pack process retained their palatability slightly better than those canned in nitrogen. Nitrogen-pack products in turn were slightly better than air-pack meat.

Compressing dehydrated meat, besides making it more compact, reduced oxidation and contributed to the prevention of rancidity.

To insure a product that will later absorb water and approach its original condition, the dehydration process should not harden the surfaces of the ground meat particles.

The protein of dehydrated pork, beef, and mutton, as determined by rat-feeding tests, was of relatively high growth promoting value and digestibility.

The vitamin content of dehydrated meats varied widely. Thiamine content was most affected by the dehydration process and was also affected by storage. Losses of riboflavin and nicotinic acid were relatively small.

The investigators in the project aided Federal purchasing agents and representatives of the meat industry in preparing specifications for dehydrated beef and pork and otherwise helped in the commercial application of the research findings.

The report, of 48 pages, is designated Circular 706, "Meat Dehydration, A Report of Research Work for its Commercial Development."

R. H. O.